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Nuclear Weapons: The Reliable Replacement Warhead Program

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Summary

Most current U.S. nuclear warheads were built in the 1980s, and are being retained longer than was planned. Yet warheads deteriorate and must be maintained. The current approach monitors them for signs of aging. When problems are found, a Life Extension Program (LEP) rebuilds and replaces components. Modifying some critical components would require a nuclear test, but a nuclear test moratorium is in effect. Therefore, LEP rebuilds these components as closely as possible to original specifications. Using this approach, the Secretaries of Defense and Energy have certified stockpile safety and reliability for the past nine years without nuclear testing.

In the FY2005 Consolidated Appropriations Act, Congress provided $9 million to initiate the Reliable Replacement Warhead (RRW) program. That program will study trading off features important in the Cold War, such as high yield and low weight, to gain features more valuable now, such as lower cost, greater ease of manufacture and certification, and increased long-term confidence in the stockpile. It plans to make these improvements by redesigning warheads without adding military capability, while LEP makes changes mainly to maintain existing weapons. Representative David Hobson, RRW's prime sponsor, views it as part of a comprehensive plan for the nuclear weapons enterprise that would also modernize the nuclear weapons complex, avoid new weapons and nuclear testing, and permit a reduction in non-deployed weapons. The FY2006 request is $9.4 million.

RRW supporters assert LEP will become harder to sustain for the long term as small changes accumulate, making it harder to certify warhead reliability and safety and perhaps requiring nuclear testing. Supporters believe RRW will enable design of replacement components for existing warheads that will be easier to manufacture and certify without nuclear testing, and will permit the military to eliminate many non-deployed warheads it maintains, at high cost, to hedge against potential warhead or geopolitical problems. Skeptics believe LEP and related programs can maintain the stockpile indefinitely. They worry that RRW's changes may reduce confidence and make a return to testing more likely. They question cost savings; even if RRW could lower operations and maintenance cost, its investment cost would be high. They are concerned that RRW could be used to build new weapons that would require testing. They note that there are no military requirements for new weapons.

At issue for Congress is which approach — LEP, RRW, some combination, or something else — will best maintain the nuclear stockpile indefinitely. RRW also bears on other issues of interest to Congress: new weapons development, nuclear testing, restructuring of the nuclear weapons complex, costs of nuclear programs, and nuclear nonproliferation. Both Houses passed energy and water appropriations bills (H.R. 2419) containing around $25 million for RRW, and the defense authorization bills as passed by the House (H.R. 1815) and reported by the Senate Armed Services Committee (S. 1042) contain the requested amount. Given congressional support, NNSA and others are beginning to implement RRW; a design competition for a warhead using the RRW approach is underway. This report also contains questions for Congress. It will be updated.

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Background

Issue Definition

Nuclear warhead components deteriorate with age. Without periodic maintenance, warheads might not detonate as intended or might fail to meet safety, security, and other requirements. Congress is considering alternate methods to maintain the nuclear stockpile for the long term. The current method, the Life Extension Program (LEP), replaces deteriorated components. Some components, such as the outer casing or certain electronics, can be modified confidently without nuclear testing. Modifying other components would require testing, but a nuclear test moratorium, in effect since 1992, forecloses that route. Instead, LEP replaces such components with ones that are newly produced using original designs and, insofar as possible, original materials.

Congress created a program, Reliable Replacement Warhead (RRW), in the FY2005 Consolidated Appropriations Act, P.L. 108-447, to study a new approach to maintaining warheads over the long term. RRW would redesign components to be easier to manufacture, among other characteristics. (See "Implementing RRW," below, for the current relationship between study and design.) The Nuclear Weapons Council, a joint Department of Defense (DOD) and Department of Energy (DOE) organization that oversees nuclear weapons activities, views RRW as the foundation of a plan to transform the entire nuclear weapons enterprise to one with a smaller yet more capable production base and far fewer spare warheads. The issue for Congress is how best to maintain the nuclear stockpile and its supporting infrastructure for the long term. A decision on this issue is important because, through it, Congress may affect the characteristics of U.S. nuclear forces; their ability to carry out their assigned missions; perceptions of U.S. nuclear nonproliferation policy; the capabilities and modernization of the nuclear weapons complex; and the nuclear weapons budget.

Many find RRW to be confusing because it is a new program and descriptions of it have changed. To provide a clearer understanding of what RRW seeks to achieve, this report (1) describes the current LEP and difficulties ascribed to it by its critics; (2) shows how post-Cold War changes in constraints may open opportunities to improve long-term warhead maintenance and reach other goals; (3) describes RRW and its pros and cons; and (4) presents issues, questions, and options for Congress. The report tracks action on the FY2006 request, and describes implementation of RRW. A brief appendix describes nuclear weapon design and operation, and the nuclear weapons complex. This report does not consider the larger questions of retaining U.S. nuclear weapons or the strategic uses and values of such weapons.

A note on terminology: RRW is in the early stages of study. It has not produced any hardware. This report refers to "RRW components" and "RRW warheads" as shorthand for components that might be developed under RRW, should that program proceed successfully, and warheads incorporating RRW components.

Congress, Nuclear Policy, and RRW

Congress has been involved with nuclear weapons issues since the Manhattan Project of World War II,[1] addressing issues ranging from strategy and doctrine to force structure and operations.

In the Floyd D. Spence National Defense Authorization Act for FY2001 (P.L. 106-398), section 1041, Congress directed the Administration to undertake a Nuclear Posture Review (NPR). This review, which the Administration presented to Congress in January 2002, set forth a new view of the role of nuclear weapons in U.S. defense policy.[2] It recognized that the strategic relationship with Russia had changed dramatically since the end of the Cold War, and that new and poorly-defined threats could emerge. Accordingly, it called for a change in the nuclear posture from one based on countering a specific threat from the Soviet Union to one that would have a set of capabilities to counter a range of potential future threats, such as the increasing use by potential adversaries of hardened and deeply buried facilities. These capabilities were unified in a "New Triad." Beginning in the early 1960s, the United States had a "triad" of nuclear forces — bombers, land-based intercontinental ballistic missiles, and submarine-launched ballistic missiles. The New Triad included (1) offensive strike capabilities, which combined the "old" nuclear triad with precision strike conventional forces; (2) missile defenses; and (3) an industrial infrastructure, nuclear and nonnuclear, responsive to DOD's needs.

The Administration has indicated that it welcomes a dialog with Congress on broad nuclear policy.[3] At the same time, Congress has tended to focus on several

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[1] Richard Hewlett and Oscar Anderson, Jr., *A History of the United States Atomic Energy Commission: Volume I, The New World, 1939/1946*, (University Park, PA: Pennsylvania State University Press, 1962), pp. 289-290, discusses the handling of appropriations for the project.

[2] The NPR was prepared in classified form; DOD provided unclassified briefing slides and an unclassified briefing on it. For the briefing, see J.D. Crouch, Assistant Secretary of Defense for International Security Policy, U.S. Department of Defense, *Special Briefing on the Nuclear Posture Review*, Jan. 9, 2002, at [http://www.defenselink.mil/transcripts/2002/t01092002_t0109npr.html]. For the slides, see U.S. Department of Defense, "Findings of the Nuclear Posture Review," Jan. 9, 2002, at [http://www.defenselink.mil/news/Jan2002/020109-D-6570C-001.pdf]. See also CRS Report RL31623, *NuclearWeapons: Changes in Policy and Force Structure*, by Amy Woolf.

[3] In a prepared statement to Congress, General James Cartwright, USMC, said: "And finally, as an element of our role as steward of the nation's strategic nuclear capabilities, we

(continued...)

specific issues. In the FY2005 budget cycle, for example, it focused on the Robust Nuclear Earth Penetrator (RNEP), often called the "bunker buster," a study to determine if an existing nuclear bomb could be modified to penetrate the ground before exploding to increase its effectiveness against buried targets. Congress also considered the Advanced Concepts Initiative (ACI), a program to study nuclear weapon-related technologies.[4]

In debate on FY2005 defense authorization bills, the House and Senate defeated amendments to terminate RNEP and ACI, leaving the full amount requested, $27.6 million for RNEP and $9.0 million for ACI, in the FY2005 National Defense Authorization Act (P.L. 108-375). In contrast, the House Appropriations Committee's energy and water bill eliminated funding for both programs at the urging of Representative David Hobson, Chairman of the Energy and Water Development Appropriations Subcommittee. That subcommittee has jurisdiction over the National Nuclear Security Administration (NNSA), which operates the nuclear weapons program. This position was not challenged on the House floor. The Senate Appropriations Committee did not report an energy and water bill for FY2005. Conferees on the FY2005 Consolidated Appropriations Act (P.L. 108-447), which included energy and water provisions, followed the House position on RNEP and ACI and, at the urging of Representative Hobson, transferred all ACI funds to RRW, a new program created by the bill. The entire description of RRW in the conference report was a "program to improve the reliability, longevity, and certifiability of existing weapons and their components."[5]

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[3] (...continued)
need you to ... [c]onsider a new national dialogue on nuclear policy." Statement of General James E. Cartwright, USMC, Commander, United States Strategic Command, before the Senate Armed Services Committee, Strategic Forces Subcommittee, *Strategic Forces and Nuclear Weapons Issues in Review of the Defense Authorization Request for Fiscal Year 2006*, Apr. 4, 2005, pp. 15-16. NNSA Administrator Linton Brooks, in a prepared statement to Congress, said, "The Administration is eager to work with the Congress to forge a broad consensus on an approach to stockpile and infrastructure transformation." "Statement of Ambassador Linton F. Brooks, Administrator, National Nuclear Security Administration, U.S. Department of Energy, before the Senate Armed Services Committee, Subcommittee on Strategic Forces," Apr. 4, 2005, p. 7. Hereinafter "Brooks statement to Senate Armed Services Committee, Apr. 4, 2005."

[4] For history and technology of these programs, see CRS Report RL32130, *Nuclear Weapon Initiatives: Low-Yield R&D, Advanced Concepts, Earth Penetrators, Test Readiness.*, by Jonathan Medalia. For the current situation with RNEP, see CRS Report RL32347, *"Bunker Busters": Robust Nuclear Earth Penetrator Issues, FY2005 and FY2006*, by Jonathan Medalia.

[5] U.S. Congress, Committee of Conference, *Making Appropriations for Foreign Operations, Export Financing, and Related Programs for the Fiscal Year Ending September 30, 2005, and For Other Purposes*, report to accompany H.R. 4818, 108th Cong., 2nd Sess., 2004, H.Rept. 108-792, reprinted in U.S. Congress, *Congressional Record*, Nov. 19, 2004, Book II: H10556.

Consistent with congressional action, NNSA included $9.4 million for RRW in its FY2006 budget request.[6] Like the description in the conference report, the request takes a narrow view of RRW, stating that that program "is to demonstrate the feasibility of developing reliable replacement components that are producible and certifiable for the existing stockpile. The initial focus will be to provide cost and schedule efficient replacement pits [see Appendix] that can be certified without Underground Tests."[7]

Based on such statements, and on discussions with adherents of various points of view, it appears that RRW can be described as follows:

> RRW is a new congressionally-mandated program. Under it, the National Nuclear Security Administration (NNSA) will conduct a two-year study beginning in FY2005 to determine if a new philosophy for refurbishing nuclear warheads to reflect current constraints and opportunities can lead to a process for manufacturing warheads and certifying their performance. It appears that this process has as its direct goal the manufacture, within a decade, of new-design replacement warhead components using best modern manufacturing practices to give future nuclear weapon designers and manufacturers increased confidence, without nuclear testing, in their ability to maintain warheads so that they will perform as intended over the long term. Other goals include increased ease of manufacture and certification, increased responsiveness to possible future military requirements, reduced life cycle cost, reduced likelihood of nuclear testing, increased weapon safety and security, and increased responsiveness to environmental, safety, and health concerns
>
> To achieve these goals, RRW would make several key tradeoffs, sacrificing (assuming Department of Defense approval) warhead characteristics important during the Cold War but less so now, such as weight, size, yield, and efficiency.
>
> The main difference between RRW and the current approach to stockpile maintenance, the Life Extension Program (LEP), is one of an underlying philosophy. Under RRW, NNSA would make changes to weapon components, including those in the nuclear explosive package in an effort to attain the foregoing goals. Under LEP, NNSA makes changes chiefly to maintain weapons, and in particular minimizes changes to the nuclear explosive package. Most of the changes under RRW probably could be made under LEP. However, they probably would not be because LEP strives to hold changes to a minimum.

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[6] To clarify a point of confusion, the FY2006 NNSA budget request shows an aggregate request for FY2006-FY2010 of $97.1 million. NNSA had insufficient time between December 8, 2004, when P.L. 108-375 was signed, and February 7, 2004, when the budget request was sent to Congress, to prepare a detailed program and cost estimate. Further, Congress had directed that NNSA transfer ACI funds to RRW for FY2005. Accordingly, NNSA relabeled the ACI budget line as RRW. Thus the $97.1 million should be viewed as a placeholder, not an estimate. Note: budget figures are from U.S. Department of Energy, Office of Management, Budget, and Evaluation/CFO, *FY2006 Congressional Budget Request,* vol. I, National Nuclear Security Administration, DOE/ME-0046, Feb. 2005, p. 68. NNSA provided information on the change from ACI to RRW.

[7] Department of Energy, *FY2006 Congressional Budget Request*, Volume I, p. 82.

Supporters anticipate that RRW will offer a path to two larger goals: replacing a large nuclear weapons stockpile with fewer but more reliable weapons, and restructuring the nuclear weapons complex into one that is smaller, safer, more efficient, more responsive, and less costly. Skeptics question whether some of the tradeoffs and goals are feasible, necessary, or worth potential costs and risks.

The Need to Maintain Nuclear Warheads for the Long Term

Nuclear warheads must be maintained because they contain thousands of parts that deteriorate at different rates. Some parts, such as tritium reservoirs and neutron generators,[8] and materials, such as tritium, have well-known life limits, while the service life of other parts may be unknown or revealed only by multiple inspections of a warhead type over time. A 1983 report arguing that maintenance requires nuclear testing, stated:

> Certain chemically reactive materials are inherently required in nuclear weapons, such as uranium or plutonium, high explosives, and plastics. The fissile materials, both plutonium and uranium, are subject to corrosion. Plastic-bonded high explosives and other plastics tend to decompose over extended periods of time. ... portions of materials can dissociate into simpler substances. Vapors given off by one material can migrate to another region of the weapon and react chemically there. ... Materials in the warhead electrical systems ... can produce effluents that can migrate to regions in the nuclear explosive portion of the weapon. ... The characteristics of high explosives can change with time. ... Vital electrical components can change in character ...[9]

A 1987 report, written to rebut the contention of the foregoing report that nuclear testing is needed to maintain nuclear weapons, nonetheless agreed that aging affects weapon components:

> It should also be noted that nuclear weapons engineering has benefitted from a quarter century of experience in dealing with corrosion, deterioration, and creep since the time that the W45, W47, and W52 [warheads] entered the stockpile in the early sixties (just after the test moratorium of 1958-1961). ... Most of the reliability problems in the past have resulted from either an incomplete testing program during the development phase of a weapon or the aging and deterioration of weapon components during deployment.[10]

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[8] U.S. General Accounting Office, *Nuclear Weapons: Capabilities of DOE's Limited Life Component Program to Meet Operational Needs,* GAO/RCED-97-52, Mar. 5, 1997, available at [http://www.globalsecurity.org/wmd/library/report/gao/rced97052.htm].

[9] "Some Little-Publicized Difficulties with a Nuclear Freeze," Prepared by Dr. J.W. Rosengren, R&D Associates, under Contract to the Office of International Security Affairs, U.S. Department of Energy, October 1983, p. 5-6; reprinted in U.S. Congress. Senate. Committee on Foreign Relations. *Nuclear Testing Issues.* 99th Congress, 2nd Session, Senate Hearing 99-937, 1986, p. 167-168.

[10] Ray Kidder, *Stockpile Reliability and Nuclear Test Bans: Response to J.W. Rosengren's Defense of His 1983 Report,* Lawrence Livermore National Laboratory, UCID-20990, Feb. 1987, pp. 4-5.

Some feel that deterioration, while a potential problem, has been overstated. A scientific panel writing in 1999 stated,

> there is no such thing as a "design life." The designers were not asked or permitted to design a nuclear weapon that would go bad after 20 years. They did their best on a combination of performance and endurance, and after experience with the weapon in storage there is certainly no reason to expect all of the nuclear weapons of a given type to become unusable after 20 or 25 years. In fact, one of the main goals of SBSS [Science-Based Stockpile Stewardship, an earlier term for the Stockpile Stewardship Program, discussed below] is to predict the life of the components so that remanufacture may be scheduled, and results to date indicate a margin of surety extending for decades. ... Until now, clear evidence of warhead deterioration has not been seen in the enduring stockpile, but the plans for remanufacture still assume that deterioration is inevitable on the timescale of the old, arbitrarily defined "design lives." [11]

The deterioration noted above pertained to warheads designed in the 1950s and early 1960s and no longer deployed; newer warheads correct some of these problems. As knowledge of warhead performance, materials, and deterioration increases, the labs are able to correct some problems and forestall others. Still other aging problems have turned out to occur at a slower pace than was feared. In particular, it was long recognized that plutonium would deteriorate as it aged, but it was not known how long it would take for its deterioration to impair warhead performance. Now, studies are underway to find out, and the current best estimate is that it would take at least 45 to 60 years.

Any consequences of deterioration problems that arose during the Cold War were limited in their duration because warheads had little time to age. The United States introduced generation after generation of new nuclear "delivery vehicles" — bombers, missile submarines, and land-based missiles — each of which would typically carry a new-design warhead tailored to its characteristics and mission. A warhead for a new missile, for example, might have to withstand a higher acceleration, have a higher explosive yield, and be constrained to a specific volume. New warheads were usually introduced long before the warheads they replaced reached the end of their service lives. Two trends concerning deterioration have emerged since the end of the Cold War: (1) Stockpile Stewardship and other tools, described below, have greatly increased NNSA's understanding of warhead deterioration and how to deal with or prevent it. Also, by maintaining the current set of warhead designs for many years, design and production errors have been subjected to systematic identification and elimination and (2) Nuclear warheads have much more time to age, as warheads expected to remain in the stockpile for at most 20 years are retained indefinitely. Further, understanding of deterioration, while improving, is not perfect; surprises may still occur. As a result, deterioration remains a concern.

Nuclear warheads must be maintained so that the United States, its friends and allies, and its adversaries will be confident about the effectiveness of U.S. nuclear

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[11] Sidney Drell, Raymond Jeanloz, et al., *Remanufacture*, MITRE Corporation, JASON Program Office, JSR-99-300, Oct. 1999, pp. 4, 8.

forces. Yet warheads are hard to maintain not only because of deterioration, but also because they were designed to an exacting set of constraints. They had to meet so-called Military Characteristics set forth by DOD in consultation with DOE that specified safety parameters, weight, size, and yield, as well as the conditions a warhead would encounter in its lifetime, such as temperature and acceleration. Design compromises were made to meet these constraints. For example, beryllium was used in warheads even though it is toxic and hard to machine, and more energetic explosives were sometimes used instead of substantially less energetic ones despite an increased safety risk. Design was usually done with little consideration for ease of manufacture. Ambassador Linton Brooks, NNSA Administrator, has said that to meet the various requirements, especially maximizing yield while minimizing size and weight, "we designed these systems very close to performance cliffs."[12] That is, designs approached the point at which warheads would fail.[13]

A consequence of this design approach was that warhead components could be hard to replicate. Indeed, according to Ambassador Brooks, "it is becoming more difficult and costly to certify warhead remanufacture. The evolution away from tested designs resulting from the inevitable accumulations of small changes over the extended lifetimes of these systems means that we can count on increasing uncertainty in the long-term certification of warheads in the stockpile."[14]

At issue is whether warheads can be maintained despite the absence of nuclear testing by replacing deteriorated components with newly-made ones built as close as possible to the original specifications. This debate has been going on for decades. In a 1978 letter to President Carter, three weapons scientists argued that the United States could go to great lengths in remanufacturing weapon components:

> it is sometimes claimed that remanufacture may become impossible because of increasingly severe restrictions by EPA or OSHA to protect the environment of the worker. ... if the worker's environment acceptable until now for the use of asbestos, spray adhesives, or beryllium should be forbidden by OSHA regulations, those few workers needed to continue operations with such material could wear plastic-film suits ... It would be wise also to stockpile in appropriate storage facilities certain commercial materials used in weapons manufacture which might in the future disappear from the commercial scene.[15]

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[12] U.S. Congress, Senate Committee on Armed Services, Subcommittee on Strategic Forces, *Strategic Forces/Nuclear Weapons Fiscal Year 2006 Budget*, hearing, Apr. 4, 2005.

[13] For example, if designers calculated that a certain amount of plutonium was the minimum at which the warhead would work, they might add only a small extra amount as a margin of assurance.

[14] Brooks statement to Senate Armed Services Committee, Apr. 4, 2005, p. 3.

[15] Letter from Norris Bradbury, J. Carson Mark, and Richard Garwin to President Jimmy Carter, Aug. 15, 1978, reprinted in U.S. Congress, House Committee on Foreign Affairs and Its Subcommittee on Arms Control, International Security and Science, *Proposals to Ban Nuclear Testing*, H.J.Res. 3, 99th Congress, 1st Sess., hearings, (Washington: GPO, 1985), p. 215.

However, in a 1987 report, three scientists at Lawrence Livermore National Laboratory stated:

- *Exact replication, especially of older systems, is impossible.* Material batches are never quite the same, some materials become unavailable, and equivalent materials are never exactly equivalent. "Improved" parts often have new, unexpected failure modes. Vendors go out of business ...
- *Documentation has never been sufficiently exact to ensure replication. ...* We have never known enough about every detail to specify everything that may be important. ...
- *The most important aspect of any product certification is testing; it provides the data for valid certification.*[16]

Clearly, if components could be remanufactured to identical specifications, using identical materials, indefinitely, then warheads could be maintained in this manner as long as needed, with little in the way of scientific advances required. But NNSA holds that a more comprehensive program is needed.

The Solution So Far: The Life Extension Program

With the end of the Cold War, the nuclear weapons complex, like the rest of the defense establishment, faced turmoil. Budgets and personnel were reduced, design of new weapons ended, and a test moratorium began. For a time, the chief concern of DOE's nuclear weapons management was survival of the nuclear weapons complex.

To address this concern and set a course for the nuclear weapons enterprise, Congress, in the FY1994 National Defense Authorization Act (P.L. 103-160), Section 3138, directed the Secretary of Energy to "establish a stewardship program to ensure the preservation of the core intellectual and technical competencies of the United States in nuclear weapons, including weapons design, system integration, manufacturing, security, use control, reliability assessment, and certification." Since then, the Clinton and Bush Administrations have requested, and Congress has approved, tens of billions of dollars for this Stockpile Stewardship Program (SSP), which is presented in NNSA's budget as "Weapons Activities."

SSP uses data from past nuclear tests, small-scale laboratory experiments, large-scale experimental facilities, examination of warheads, and the like to improve theoretical understanding of the science underlying nuclear weapons performance. In turn, it uses this knowledge to improve computer "codes" that simulate aspects of weapons performance, revealing aspects of this performance and filling gaps in the nuclear weapons laboratories' understanding of it. Such advances enable scientists

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[16] George Miller, Paul Brown, and Carol Alonso, *Report to Congress on Stockpile Reliability, Weapon Remanufacture, and the Role of Nuclear Testing,* Lawrence Livermore National Laboratory, UCRL-53822, Oct. 1987, p. 25. For an opposing view, see R.E. Kidder, *Maintaining the U.S. Stockpile of Nuclear Weapons During a Low-Threshold or Comprehensive Test Ban,* Lawrence Livermore National Laboratory, UCRL-53820, Oct. 1987, esp. pp. 6-9. See also CRS Report 98-519 F, *Nuclear Weapons Production Capability Issue*, by Jonathan Medalia, esp. pp. 97-102.

to analyze data from past nuclear tests more thoroughly, "mining" it to extract still more information. Theory, simulation, and data reinforce each other: theory refines simulation, simulation helps check theory, theory and simulation guide researchers to look for certain types of data, and data help check simulation and theory.

A key task of the weapons complex is to monitor warheads for signs of actual or future deterioration. This work is done through a program that conducts routine surveillance of warheads in the stockpile by closely examining 11 warheads of each type per year to search for corrosion, gases, and other evidence of deterioration. Of the 11, one is taken apart for destructive evaluation, while the other 10 are evaluated nondestructively and returned to the stockpile.[17] In addition, an Enhanced Surveillance Program (ESP) supports surveillance; its goal "is to develop diagnostic tools and predictive models that will make it possible to analyze and predict the effects that aging may have on weapon materials, components, and systems."[18]

When routine surveillance detects warhead problems, the nuclear weapons program applies knowledge gained through SSP to fix problems through the Life Extension Program (LEP). It attempts "to extend the stockpile lifetime of a warhead or warhead components at least 20 years with a goal of 30 years"[19] in addition to the originally-anticipated deployment time.

A warhead's components may be divided into two categories: those that are part of the nuclear explosive package (NEP), and those that are not. As described in the Appendix, the NEP is the part of the warhead that explodes, as distinct from the more numerous components like the outer case or arming system. Because non-NEP components can be subjected to extensive experiments and nonnuclear laboratory tests, they can be modified as needed under LEP to incorporate more advanced electronics or better materials. In sharp contrast, NEP components cannot be subjected to nuclear tests because the United States has observed a moratorium on nuclear testing since 1992. As a result, LEP seeks to replicate these components using original designs and, insofar as possible, original materials. In this way, it is hoped, components will be close to the originals so that they can be qualified for use in warheads. Because NEP components cannot be tested while other components can be, long-term concern focuses on NEP components.

Warheads contain several thousand components. While not all need to be refurbished in an LEP, some are difficult to fabricate. As a result, the LEP for a particular warhead is a major campaign with extensive preparatory analysis and detailed work on many components that can take many years. For example, NNSA describes the LEP for the W76 warhead for Trident submarine-launched ballistic missiles as follows:

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[17] Information provided by NNSA, May 9, 2005.

[18] Katie Walter, "Enhanced Surveillance of Aging Weapons," *Science & Technology Review*, Jan./Feb. 1998, p. 21.

[19] Department of Energy, *FY2006 Congressional Budget Request*, vol. I, p. 75. For a weapon-by-weapon description of LEP activities planned for FY2006, see ibid., pp. 75-76.

> The W76 Life Extension Program will extend the life of the W76 for an additional 30 years with the FPU [first production unit] in FY 2007. Activities will include design, qualification, and certification activities to ensure the design of the refurbished warheads meets all required military characteristics; work associated with the manufacturability of the components including the nuclear explosive package; the Arming, Fuzing, and Firing (AF&F) system; the gas transfer system; and the associated cables, elastomers, valves, pads, foam supports, telemetries, and miscellaneous parts.[20]

Stockpile stewardship has made great strides in understanding weapons science, in predicting how weapons will age, and in predicting how they will fail. Most observers agree with the following assessment by Ambassador Brooks in congressional testimony of April 2005:

> today *stockpile stewardship is working,* we are confident that the stockpile is safe and reliable, and there is no requirement at this time for nuclear tests. Indeed, just last month, the Secretary of Energy and Secretary of Defense reaffirmed this judgment in reporting to the President their ninth annual assessment of the safety and reliability of the U.S. nuclear weapons stockpile. ... Our assessment derives from ten years of experience with science-based stockpile stewardship, from extensive surveillance, from the use of both experiments and computation, and from professional judgment.[21]

Is LEP Satisfactory for the Long Term?

In the turmoil following the end of the Cold War, it is scarcely surprising that the method chosen to maintain the stockpile — a task that had to be performed in the face of the many changes affecting the weapons complex, and the many unknowns about its future — was to minimize changes. Now, with SSP well established, NNSA feels that it is appropriate to use a different approach to warhead maintenance, one that builds on the success of SSP but that challenges the notion underlying LEP that changes must be held to a minimum.

Advocates of RRW recognize that LEP has worked well but, as discussed below, charge that it uses the wrong methods to maintain the wrong stockpile. Their concern is not with maintaining reliability of warheads over the near term, but of maintaining it over the long term. They assert that LEP is not suited to the task because it will become harder to make it work as the technology under which current warheads were created becomes increasingly archaic and as materials, equipment, processes, and skills become unavailable. If the labs were to lose confidence that they could replicate NEP components to near-original designs using near-original materials and processes, the United States could ultimately face a choice between resuming nuclear tests or accepting reduced confidence in reliability.

Criticism of LEP starts with a particular view of nuclear strategy and the nuclear stockpile. The current stockpile, most units of which were manufactured between

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[20] Department of Energy, *FY2006 Congressional Budget Request,* Volume I, p. 75.

[21] Brooks statement to Senate Armed Services Committee, April 4, 2005, p. 2. Original emphasis.

1979 and 1989, was designed to deter and, if necessary, defeat the Soviet Union. Now, as noted, threat, strategy and missions have changed. Accordingly, in this view, the United States has the wrong stockpile for current circumstances. Ambassador Brooks said that current warheads are wrong technically because "we would [now] manage technical risk differently, for example, by 'trading' [warhead] size and weight for increased performance margins, system longevity, and ease of manufacture." These warheads were not "designed for longevity" or to minimize cost, and may be wrong militarily because yields are too high and "do not lend themselves to reduced collateral damage." They also lack capabilities against buried targets or biological and chemical munitions, and they do not take full advantage of precision guidance.[22] Furthermore, LEP's critics believe the stockpile is wrong politically because it is too large:

> We retain "hedge" warheads in large part due to the inability of either today's nuclear infrastructure, or the infrastructure we expect to have when the stockpile reductions are fully implemented in 2012, to manufacture, in a timely way, warheads for replacement or for force augmentation, or to act to correct unexpected technical problems.[23]

Finally, they believe the stockpile is wrong in terms of physical security because it was not designed for a scenario in which terrorists seize control of a nuclear weapon and try to detonate it in place. New use control technologies would permit NNSA to reduce the cost of "gates, guns, guards."[24]

RRW and the Transformation of Nuclear Warheads

The U.S. nuclear stockpile was designed within Cold War constraints, requirements, and opportunities. While the requirement for warheads to be safe and reliable remains constant, many other constraints have changed — indeed, inverted — over the past 15 years, and new opportunities and requirements have emerged as well. As a result, RRW advocates claim, it is both necessary and feasible to transform the stockpile to reflect these changes.

With RRW, NNSA hopes to revisit tradeoffs underlying the current stockpile to enable it to adapt to changes over the past 15 years and meet possible future requirements. While RRW would change many tradeoffs significantly, the changes would, in NNSA's view, work out well: NNSA would trade negligible sacrifices to secure major gains. For example, NNSA would consider relaxing constraints on yield and yield-to-weight, assuming DOD approved. So doing would enable NNSA to move to simpler designs, which would be essential in an environment without nuclear testing. NNSA would strive to minimize the use of hazardous materials, and relaxing constraints on yield and on yield to weight would make it easier to do so. The balance of this section presents some Cold War warhead requirements, how they have changed, and implications of these changes.

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[22] Ibid., pp. 2-3.

[23] Ibid., p. 3.

[24] Ibid., p. 4.

Efficiency. A major characteristic of warheads for ballistic and cruise missiles was a high "yield-to-weight ratio" — that is, maximizing a warhead's explosive force (yield) for a given weight.[25] Reducing weight let each missile carry more warheads to more distant targets; increasing yield gave each warhead a better chance of destroying its target; and increasing yield-to-weight enabled these goals to be met at the same time. For example, the W88 warhead for the Trident II submarine-launched ballistic missile used a conventional high explosive (CHE) that was more sensitive to impact than an alternative, insensitive high explosive (IHE), used on many other warhead types. IHE provided greater safety, but CHE packed substantially more energy per unit weight. A missile could carry the lighter CHE warheads to a greater distance, so that a submarine could stand off farther from its targets. Increased ocean patrol area forced the Soviet Union to spread out its antisubmarine assets, improving submarine survivability. Hard-to-manufacture designs, hazardous materials, and other undesirable features were deemed acceptable design tradeoffs to maximize yield-to-weight. Now, ballistic missiles carry fewer warheads than they did during the Cold War due to reduced targeting requirements. As a result, it is possible to revisit the Cold War tradeoffs, redesigning warhead components to give greater emphasis to other characteristics at the expense of yield, weight, or both. For example, with a missile's carrying capacity divided among fewer warheads, each warhead can be somewhat heavier,[26] and the added permissible weight might be allocated to design features that made a warhead easier to manufacture.

Yield. During the Cold War, DOD required a substantial yield for its strategic warheads. Yield compensated for inaccuracy in attacking targets such as missile silos, which were hardened to withstand all but near misses or direct hits. Yield was also important for attacking targets covering large areas, such as shipyards or petroleum refineries. Now, high yield is much less important. There are likely to be fewer area targets in the future. Precision guidance enables conventional bombs to score direct hits on targets, and similar technology could apparently be used to make missile-delivered nuclear warheads more accurate, permitting lower yield. Indeed, some argue that the United States needs some lower-yield warheads.[27] In this view, lower-yield warheads would create less of the unintended damage that might prevent the United States from using them. Such warheads, some argue, would be a better deterrent precisely because their use would be more credible.

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[25] Bombs were less constrained in weight because bombers carry heavier loads than missiles.

[26] Ballistic missiles carry warheads inside reentry vehicles (RVs). An RV is a streamlined shell that protects its warhead from the intense heat and other stresses of reentering the atmosphere at high speed. RVs are designed to carry a specific type of warhead on a specific missile; the maximum stress that the RV encounters is carefully studied. Increasing warhead weight significantly would increase these stresses, possibly causing the RV to fail and the warhead to burn up, fail, or miss its target by a wide margin.

[27] Bryan Fearey, Paul White, John St. Ledger, and John Immele, "An Analysis of Reduced Collateral Damage Nuclear Weapons," *Comparative Strategy*, Oct./Nov. 2003, pp. 313-315. These lower-yield weapons are not necessarily the very low yield "mini-nukes" debated in Congress in recent years.

Nuclear testing. Between 1945 and 1992, the United States conducted over 1,000 nuclear tests, most of which were for weapons design.[28] These tests provided confidence that a weapon incorporating hard-to-manufacture components was made correctly, that a weapon would work at the extremes of temperatures to which it might be exposed, and that the design was satisfactory in other ways. Testing also enabled the labs to validate changes to existing warhead designs. With the congressionally-imposed U.S. nuclear test moratorium in October 1992,[29] the United States can no longer rely on tests to validate designs. While there are no military requirements for nuclear weapons with new or modified military capabilities,[30] any future weapon would have to be more conservatively designed than those that could be tested, such as by increasing the yield of the primary to increase confidence in its ability to ignite the secondary, and by staying within design parameters that past nuclear tests have validated. This conservatism also applies to modifications of components.

Performance, schedule, and cost tradeoffs. Performance has always been the dominant consideration for nuclear weapons. Weapons must meet standards for safety and reliability, and meet other military characteristics. During the Cold War, schedule was also critical. With new missiles and nuclear-capable aircraft entering the force at a sustained pace, warheads and bombs had to be ready on a schedule dictated by their delivery systems. As a result, "our nuclear warheads were not designed ... to minimize DOE and DoD costs."[31] Now, reducing cost has a higher priority. Cost reduction is also more feasible: performance is still dominant, but no external threat drives the schedule.

Environment, safety, and health (ES&H). During much of the Cold War, the urgency of production and the limited knowledge of the ES&H effects of materials used or created in the nuclear weapons enterprise resulted in the use of hazardous materials, dumping contaminants onto the ground or into rivers, exposing citizens to radioactive fallout from nuclear tests, and the like. Now, ES&H concerns have grown within the nuclear weapons complex, reflecting their rise in civil society at large, leading to a strong interest in minimizing the use of hazardous materials in warheads and their production.

Skill development and transfer. During the Cold War, the design of dozens of warhead types, the conduct of over 1,000 nuclear tests, and the production

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[28] The United States conducted 1,030 tests, of which 883 were weapons related. (The United Kingdom conducted another 24 tests at the Nevada Test Site.) U.S. Department of Energy, Nevada Operations Office, Office of External Affairs, *United States Nuclear Tests, July 1945 through September 1992,* DOE/NV-209, rev. 14, Dec. 1994, p. viii.

[29] The moratorium was begun pursuant to Section 507 of P.L. 102-377, FY1993 Energy and Water Development Appropriations Act, signed into law October 2, 1992.

[30] Brooks stated, "We must preserve the ability to produce weapons with new or modified military capabilities if this is required in the future. *Currently the DoD has identified no requirements for such weapons,* but our experience suggests that we are not always able to predict our future requirements." Brooks statement to Senate Armed Services Committee, Apr. 4, 2005, p. 6, emphasis added.

[31] Brooks statement to Senate Armed Services Committee, Apr. 4, 2005, p. 3.

of thousands of warheads exercised the full range of nuclear weapon skills. Now, with no design or testing, no new-design warheads being produced, and with warheads being refurbished at a slower pace than that at which they were originally produced, some have raised concern that weapons complex personnel are not adequately challenged. In this view, skill development and transfer can no longer be simply a byproduct of the work, but must be an explicit goal of the nuclear weapons program.

RRW and the Transformation of the Nuclear Weapons Enterprise

Supporters see RRW as the basis for much more than addressing warhead issues. Representative Hobson was, as noted, the prime sponsor of the effort to establish RRW. Consequently, it is important to understand his intent for the program. He expressed concern about the direction of nuclear policy. In introducing the FY2005 energy and water bill (H.R. 4614) to the House, he emphasized the need to redirect the nuclear weapons complex:

> much of the DOE weapons complex is still sized to support a Cold War stockpile. The NNSA needs to take a 'time-out' on new initiatives until it completes a review of its weapons complex in relation to security needs, budget constraints, and [a] new stockpile plan..[32]

At a National Academy of Sciences symposium in August 2004, he expressed concern about Administration nuclear policies and programs:

> I was not comfortable with the Administration's emphasis on new nuclear weapons initiatives in the fiscal year 2004 budget request and repeated in the fiscal year 2005 request. I view the Advanced Concepts research proposal, the Robust Nuclear Earth Penetrator study, and the effort to reduce the nuclear test readiness posture to 18 months as very provocative and overly aggressive policies that undermine our moral authority to argue that other nations should forego nuclear weapons. We cannot advocate for nuclear nonproliferation around the globe and pursue more useable nuclear weapon options here at home. That inconsistency is not lost on anyone in the international community.[33]

He saw RRW as a key part of his effort to redirect U.S. nuclear strategy, reshape the nuclear weapons stockpile and complex to support that strategy, undertake weapons programs consistent with that strategy, and reject those inconsistent with it.

> I think the time is now for a thoughtful and open debate on the role of nuclear weapons in our country's national security strategy. There is still a basic set of

[32] U.S. Congress, *Congressional Record*, June 25, 2004, p. H5085.

[33] Representative David Hobson, "Remarks by Chairman David Hobson — House Appropriations Subcommittee on Energy and Water Development, [to the] National Academy of Sciences, Committee on International Security and Arms Control, Symposium on 'Post-Cold War U.S. Nuclear Strategy: A Search for Technical and Policy Common Ground,'" August 11, 2004, p. 3; available at [http://www7.nationalacademies.org/cisac/Hobson_Presentation.pdf].

> questions that need to be addressed and let me talk about some of those. How large a stockpile should we maintain, should we have a set of older weapons with many spares or should we have a smaller stockpile of more modern weapons? What design and manufacturing capabilities do we need to maintain the DOE nuclear weapons complex? And where should these complexes be located? And finally, is this the best use of our limited, financial resources for national defense? ... until we have this debate and develop a comprehensive plan for the U.S. nuclear stockpile and the DOE weapons complex, we're left arguing over isolated projects such as the robust nuclear penetrator or the RNEP study. ...[34]

Representative Hobson also stated:

> The Reliable Replacement Warhead concept will provide the research and engineering problems necessary to challenge the workforce while at the same time refurbishing some existing weapons in the stockpile without developing a new weapon that would require underground testing to verify the design. A more robust replacement warhead, from a reliability standpoint, will provide the stockpile hedge that is currently provided by retaining thousands of unnecessary warheads.[35]

Thus while the FY2005 omnibus appropriations conference report and NNSA's FY2006 budget request presented a program of narrow scope, Representative Hobson envisioned that RRW could be much more consequential. NNSA Administrator Brooks agreed. In testimony of April 2005, he presented an expansive view of the transformation of the nuclear weapons enterprise, with RRW as its pivot point.

> Let me briefly describe the broad conceptual approach for stockpile and infrastructure transformation. The "enabler" for such transformation, we believe, is the RRW program. To establish the feasibility of the RRW concept, we will use the funds provided by Congress last year and those requested this year to begin concept and feasibility studies on replacement warheads or warhead components that provide the same or comparable military capabilities as existing warheads in the stockpile. If those studies suggest the RRW concept is technically feasible, and if, as I expect, the Department of Defense establishes a requirement, we should be able to develop and produce by the 2012-15 timeframe a small build of warheads in order to demonstrate that an RRW system can be manufactured and certified without nuclear testing.
>
> Once that capability is demonstrated, the United States will have the option to:
> • truncate or cease some ongoing life extension programs for the legacy stockpile,
> • apply the savings from the reduced life extension workload to begin to transform to a stockpile with a substantial RRW component that is both easier and less costly to manufacture and certify, and

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[34] Congressman David Hobson, "U.S. Nuclear Security in the 21st Century," address to the Arms Control Association, Washington, DC, Feb. 3, 2005. (Transcript as delivered.)

[35] Congressman David Hobson, "U.S. Nuclear Security in the 21st Century," address to the Arms Control Association, Washington, DC, Feb. 3, 2005. (Remarks as prepared for delivery.)

• use stockpile transformation to enable and drive consolidation to a more responsive infrastructure.[36]

DOD, as the "customer" and potential user of nuclear weapons, sets requirements for types and characteristics of nuclear weapons. Representatives of the Office of the Secretary of Defense, the armed services, and NNSA participate in the Nuclear Weapons Council, which under 10 U.S.C. 179 coordinates their efforts in this area. Clearly, if RRW is to progress, it would need the participation and support of DOD, the services, and NNSA. A first step in that direction occurred in March 2005 when the council, by unanimous vote, fully supported the RRW concept. At the same time, RRW, like any program, is subject to congressional approval, rejection, or modification.

Steve Henry, Deputy Assistant to the Secretary of Defense for Nuclear Matters, provided the following statement. It is the first detailed statement of DOD's position on RRW:[37]

> President Bush said, "I am committed to achieving a credible deterrent with the lowest possible number of nuclear weapons consistent with our national security needs, including our obligations to our allies. My goal is to move quickly to reduce nuclear forces."[38] To achieve this goal, we must have confidence in the safety, security, and reliability of the weapons not just for today, but for the long term and with the goal to reduce the likelihood of resumption of nuclear testing.
>
> Our current path does not adequately meet the President's guidance. The current stockpile was built in the 80's. These weapons are optimized for yield-to-weight and were expected to remain in the stockpile for only about 20 years. Under the current life extension program, these weapons would be refurbished to extend their life for more than 30 years beyond their original design life. Although any change to a weapon component is reviewed extensively, there remains an uncertainty on the potential impact of cumulative changes. Fundamentally, the life extension program would continue the reliance on Cold War legacy designs that use toxic and high risk materials and provide only limited opportunity to enhance safety and security with 21st century technology. Additionally, in some cases, the life extension program would require the reconstitution of expensive weapons production processes that were discontinued more than a decade ago. Under the current path, the DoD would continue to depend on non-deployed warheads to hedge against technical failures and against geopolitical changes.
>
> It is in the best interest of the United States to pursue an alternate path. In concept, a reliable replacement warhead (RRW) could provide that path. Ideally, RRW would sustain the military capabilities of the existing stockpile but may require relaxing some of the Cold War design requirements in order to use replacement components. These components would be designed to increase

[36] Brooks statement to Senate Armed Services Committee, Apr. 4, 2005, p. 6.

[37] Statement provided to the author May 3, 2005.

[38] President George W. Bush, "Remarks by the President to Students and Faculty at National Defense University," Fort Lesley J. McNair, Washington, D.C., May 1, 2001.

> margins, provide for ease of manufacture and certification, and would reduce the potential for failure due to design and manufacturing flaws and material aging issues. These RRW characteristics would improve our ability to ensure long-term confidence in the stockpile and reduce the likelihood of resumption of nuclear testing, therefore potentially reducing the number of warheads needed to hedge against technical surprises. Under the RRW concept, incorporation of modern safety and security technology would be feasible. RRW could be the enabler for the transformation to an efficient, responsive infrastructure, which may help reduce the number of warheads needed to hedge against geopolitical changes. As an example of how it would make manufacturing easier while increasing safety within the nuclear weapons complex, it could eliminate the need for many of the exotic and hazardous non-nuclear materials.
>
> RRW would, in concept, offer other advantages as well, such as the opportunity to exercise and transfer expertise. However, if we want to move from our current path to RRW, we must do it soon because experienced nuclear weapon designers with test experience are rapidly retiring.

The U.S. Strategic Command (STRATCOM), a component of DOD, is the military command that operates and, at the President's direction, would use U.S. strategic nuclear forces. It provided the following statement on RRW: "STRATCOM will be participating in the joint RRW Project Officers Group, or POG, with the NNSA, the Navy, and the Air Force, and STRATCOM's position on RRW will be based on the results of the RRW POG process."[39]

Skeptics' Views of RRW

Because the RRW program is new, not clearly defined, and may hold benefits as well as costs, those who have criticized some past nuclear weapon programs are trying to understand RRW and its implications better. As they are in the process of shaping their views, there are few outright critics of the program, but some skeptics.

Some Members of Congress take a cautious approach. A letter drafted by Representative Tauscher and others to Representatives C.W. Bill Young and David R. Obey, Chairman and Ranking Member, respectively, of the House Appropriations Committee, and signed by at least 51 Members of Congress, states that RRW "was added in the Omnibus Conference last year to replace Advanced Concepts. The scope and direction of this program must be clearly defined so that this program does not simply replace the one Congress canceled last year." Further, "We are also concerned that shifting funding from the cancelled Advanced Concepts program into the Reliable Replacement Warhead program may result in new nuclear warheads moving forward without any established need or compelling justification."[40]

Robert Peurifoy, a former Vice President of Sandia National Laboratories, feels RRW has been oversold. He sees little difference between RRW and LEP; if a component can be manufactured with materials different than the original under

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[39] Information provided by STRATCOM to the author, Apr. 29, 2005.

[40] Letter provided by Representative Tauscher's office, used by permission. For full text, see [http://www.ananuclear.org/markeys%20letter.html].

RRW, for example, why couldn't that be done under LEP? He notes that that the labs, using development, production, and stockpile data, have repeatedly certified the reliability for the nuclear explosive package of warheads at 100 percent; how, he asks, can that be improved upon? If stockpile stewardship, including LEP as one of its tools, can maintain warheads for nine years without testing, why can it not do so indefinitely? The lack of a military requirement for new-design warheads for many years, and the questionable rationales presented for such warheads in the public debate, in his view, undermines the need for a "responsive" infrastructure, as there will likely be few if any events requiring a response.[41]

Raymond Jeanloz is a Professor of Earth and Planetary Science and of Astronomy at the University of California, Berkeley, and a long-time member of scientific panels reporting on nuclear-weapon issues. His view depends on what RRW is. He supports a version of RRW that would build on the success of the Stockpile Stewardship Program (SSP) to improve manufacturing practices, lower costs and increase performance margins, as these enhancements would support the Administration's decision to significantly reduce the size of the U.S. stockpile. This RRW would stay within the design parameters that have been validated by nuclear testing. In contrast, he opposes an RRW that would move beyond those parameters in order to create new weapons, as that approach could lead to new weapons that are less reliably validated, that require testing, and that would counter U.S. nonproliferation efforts. In particular, he believes that new designs would undermine U.S. attempts to convince other nations not to develop nuclear weapons by showing them that the United States still feels the need for new weapons. Whichever form of RRW emerges, Jeanloz is concerned about the lack of clarity regarding the program and its cost.[42]

Sidney Drell, Professor Emeritus of Physics at Stanford University, and James Goodby, who held several Administration positions in arms control, including Special Representative of President Clinton for the security and dismantlement of nuclear weapons from 1995 — 1996, both have a view of RRW that depends on how technologically ambitious the program is:

> One direct way to simplify the process of certifying the reliability and effectiveness of the warheads and to sustain this confidence over a longer period of time is to increase their performance margins. An example of this is to further enhance the explosive energy provided by the primary stage of a nuclear weapon above the minimum required to ignite the secondary, or main, stage of a nuclear weapon. A straightforward way to do this that requires no explosive testing to validate is by adjusting the boost gas fill in the primary during scheduled maintenance or remanufacturing activities. This is an example of an existing process for maintaining long-term high confidence in the arsenal. It is already available, has high merit, and should continue to be implemented.[7] This approach is the appropriate focus of effort for the Reliable Replacement Warhead (RRW) program currently being funded at the U.S. national weapons laboratories.

[41] These views are drawn from discussions and emails between Mr. Peurifoy and the author, Mar.-Apr. 2005.

[42] These views are drawn from discussions and emails between Professor Jeanloz and the author, Mar.-Apr. 2005.

> Turning the RRW program into an effort to develop new-warhead designs by altering the nature of the high explosives or the amount of nuclear fuel in the primary without testing, as some have suggested, would be a mistake. It takes an extraordinary flight of imagination to postulate a modern new arsenal composed of such untested designs that would be more reliable, safe, and effective than the current U.S. arsenal based on more than 1,000 tests since 1945. A comprehensive and rigorous stockpile maintenance program confirms and sustains this high confidence. If testing is resumed, the damage to the broader nonproliferation regime, and thus to U.S. security interests, would far outweigh any conceivable advantages to be gained from the new designs.[43]

Daryl Kimball, Executive Director of the Arms Control Association, is more concerned:

> ... the [RRW] proposal is problematic. The rationale for the program is dubious, the scope is vague, and the potential effects far-reaching and dangerous. ... new replacement warheads are not necessary to preserve existing U.S. nuclear-weapon capabilities. ... the existing Stockpile Stewardship Program is working. ... the RRW program could, if not carefully circumscribed, become a back door for the administration to circumvent congressional opposition to new warhead designs for new and destabilizing nuclear strike missions. ... replacing existing, well-proven nuclear warhead designs with "new" and "improved" replacement warheads or warhead components could, if carelessly pursued, increase pressure to conduct nuclear explosive proof tests. ... So long as the United States maintains a nuclear arsenal, stockpile maintenance efforts should focus on preserving the reliability of existing warheads using methods validated by past experience.[44]

Issues and Questions for Congress

RRW, as a new program with far-reaching implications, raises many possible issues for Congress. Some of them are noted here, along with possible questions that Members may wish to ask of NNSA and of skeptics.

Are the Surveillance Program and LEP Sufficient to Maintain the Stockpile? Skeptics hold that LEP works now, can work indefinitely, and should improve over time. A 2002 report by the National Academy of Sciences stated:

> we see no reason that the capabilities of those mechanisms [for maintaining confidence in the stockpile] — surveillance techniques, diagnostics, analytical and computational tools, science-based understanding, remanufacturing capabilities — cannot grow at least as fast as the challenge they must meet. (Indeed, we believe that the growth of these capabilities — except for

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[43] Sidney Drell and James Goodby, *What Are Nuclear Weapons For? Recommendations for Restructuring U.S. Strategic Nuclear Forces*, Arms Control Association, Apr. 2005, pp. 19-20. (Footnote in original is as follows: 7. Executive Summary, JASON Report on Nuclear Testing, JSR-95-320, Aug. 1, 1995.)

[44] Daryl Kimball, "Replacement Nuclear Warheads? Buyer Beware," *Arms Control Today*, May 2005.

> remanufacturing of some nuclear components — has more than kept pace with the growth of the need for them since the United States stopped testing in 1992, with the result that confidence in the reliability of the stockpile is better justified technically today than it was then.)[45]

Skeptics argue that SSP can accommodate minor variance in components made with LEP. Variation has always been present in nuclear weapons production. During the Cold War, when thousands of warheads of a given type were made over a period of years, small changes were inevitable: materials would vary from one batch to the next, vendors would reformulate materials slightly, processes were not completely defined, and minor design or process changes were made. Even when nuclear testing was available, it was impossible to test all variations because the number of possible combinations of variables was so large. Despite these limitations, weapons were certified for use in the stockpile, indicating that some variance is acceptable.

RRW supporters argue that LEP will have increasing difficulty in maintaining weapons over the long term. Regarding testing, they recognize that it was impossible to test all possible variations affecting warheads, but argue that such testing was unnecessary because much variation fell within design parameters validated by nuclear tests. At the same time, testing was available to address uncertainties and to provide confidence in larger changes.

Possible Questions for NNSA.

Sustainability. Ambassador Brooks has emphasized that "stockpile stewardship is working," but expressed concern that there will be increased uncertainty in U.S. ability to certify warheads for the stockpile over the long term.[46] At what point will LEPs be unable to sustain confidence in nuclear weapons? What is the basis for that calculation? What is the evidence that LEP will be unable to maintain warheads over the long term?

New Warheads. Ambassador Brooks sees RRW as the enabler for transforming the nuclear weapons stockpile and infrastructure, and said, "as part of the transformation of the stockpile, we must preserve the ability to produce weapons with new or modified military capabilities if this is required in the future."[47] Why is RRW needed for this purpose? Could the labs design, and the plants produce, a new warhead in which they had high confidence without testing by using existing capabilities?

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[45] National Academy of Sciences. Committee on Technical Issues Related to Ratification of the Comprehensive Nuclear Test Ban Treaty. *Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty*. Washington, National Academy Press, 2002, p. 5.

[46] Brooks statement to Senate Armed Services Committee, Apr. 4, 2005, p. 2, 3.

[47] Ibid., p. 6.

Certification Difficulties. Ambassador Brooks has argued that "it is becoming more difficult and costly to certify warhead remanufacture."[48] What assurance is there that this trend will continue, and not level off or decline? Even if the trend were to continue, there is also a gain in the labs' ability to understand, detect, and fix stockpile problems. Are certification difficulties growing faster than advances that facilitate certification?

Possible Questions for Skeptics.

Can LEP Work for the Long Term? A key argument for RRW is that LEP looks unsustainable for the long term, whether for technical or cost reasons. In this view, LEP locks the nuclear weapons complex into maintaining components, materials, and processes that become increasingly removed from current technology, so that multiple LEPs will inevitably lead to the accretion of slight differences in weapons components over time that will undermine weapon reliability. Is that an accurate assessment?

RRW vs. LEP. Even under LEP, nonnuclear components can be modified significantly because they do not require nuclear testing. Some modifications to nuclear explosive components are inevitable under LEP. RRW nuclear explosive components would arguably stay within design parameters validated by nuclear testing. How much difference is there between RRW and LEP? Is RRW simply an extension of LEP?

Would Proceeding with LEP Preclude RRW? An argument for proceeding with RRW promptly is that the W76 and W80, which constitute the bulk of deployed warheads, will be undergoing LEPs soon. Refurbishing them with LEP, in this view, would lock NNSA into LEP and the current nuclear weapons complex for a decade to do the LEPs, and another two or three decades while these warheads remain deployed. This result, it is claimed, would preclude RRW. What should one make of this argument?

An Acceptable RRW. RRW is in the process of being defined. Is there a variant of RRW that skeptics would support? What changes to RRW in its current form would they see as essential? What limitations on the program would they recommend?

Is RRW Needed in Order to Provide New Military Capabilities? NNSA Administrator Brooks maintains that the current stockpile may be wrong from a military perspective. He argues that yields are too high, there is potential for too much collateral damage, we lack the capability to destroy buried facilities or facilities containing chemical or biological weapons, warheads could be more accurate, and they are not geared for small-scale strikes. He has said, "we must preserve the ability to produce weapons with new or modified military capabilities if this is required in the future." He views RRW as the "enabler" for transforming the stockpile.[49] Examples of warheads that might benefit from modifications to the nuclear explosive

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[48] Ibid., p. 3.

[49] Ibid., p. 3, 6.

package (NEP) to tailor radiation outputs include those to create electromagnetic pulse to destroy electronic equipment, and those to destroy chemical or biological agents.

RRW skeptics would challenge the need for new military capabilities. They maintain that current weapons possess a vast range of capabilities that should suffice for the limited contingencies in which the United States might use them. Ambassador Brooks does not claim that new capabilities are needed, only that they might be in the future. Further, they argue, many of Ambassador Brooks's examples are irrelevant to RRW. Accuracy depends mainly on the reentry vehicle and the missile's guidance. The ability to conduct small strikes depends on command and control. There may be various ways to reduce the yield, and collateral damage, of existing weapons. Unmodified weapons can generate electromagnetic pulse, as has been known since around 1960.[50] Even modified nuclear weapons may be unable to destroy chemical or biological agents in buried facilities.[51] Accordingly, critics challenge the new-capabilities argument as a rationale for RRW.

Possible Questions for NNSA. *Stockpile Needs:* Ambassador Brooks has stated that the current stockpile "may also be the wrong stockpile from a *military* perspective."[52] While there are no current requirements for new warheads, what potential future military requirements could be met only with RRW? Why is the current stockpile wrong from a military perspective, given the wide range of yields available in its weapons?

Possible Questions for Skeptics. *New Weapons:* Some argue that the United States should not build new nuclear weapons, and express concern that RRW may permit new weapons. But what, exactly, is a new weapon? Various criteria might be set forth, but none seem precisely applicable. One criterion might be a weapon that requires testing, but testing an existing weapon to fix a problem would not create a new weapon. Another criterion might be a new mission, but the Robust Nuclear Earth Penetrator, if it is ultimately deployed, would have the same mission as the B61-11 earth penetrator deployed in the 1990s, which replaces a much larger bomb for that mission, the B53, deployed decades earlier. Further, is the new-weapon debate worth having? And couldn't the nuclear weapons complex build a new weapon using LEP?

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[50] U.S. Departments of Defense and Energy, *The Effects of Nuclear Weapons.* Compiled and edited by Samuel Glasstone and Philip Dolan, (Washington: GPO, 1977), p. 514.

[51] A National Academy of Sciences report stated, "An attack [on a chemical or biological weapons facility] by a nuclear weapon would be effective in destroying the agent only if detonated in the chamber where agents are stored," and that the uncertainty of survival of an earth penetrator weapon increases with a depth of penetration greater than 3 meters. National Academy of Sciences. National Research Council. Division on Engineering and Physical Sciences. Committee on the Effects of Nuclear Earth-Penetrator and Other Weapons. *Effects of Nuclear Earth-Penetrator and Other Weapons,* (Washington: National Academies Press, 2005); prepublication copy, p. 9-1 and 9-2. By this reasoning, a nuclear attack on a chemical or biological weapon facility buried at a moderate depth would probably fail.

[52] Brooks statement to Senate Armed Services Committee, Apr. 4, 2005, p. 3.

Might RRW Permit a Reduction in Warhead Numbers? The United States retains many reserve warheads. Some are for surveillance, as described in "The Solution So Far: The Life Extension Program," above. Some hedge against a potential need for more deployed weapons, which is important because the United States has been unable to produce weapons for the stockpile since shortly after the Rocky Flats pit production plant closed in 1989. (See Appendix.) Others hedge against the failure of some weapons; for example, NNSA retains at least two warhead types for each delivery system — W62, W78, and W87 for land-based missiles, W76 and W88 for submarine-launched missiles, B61 and B83 bombs for aircraft, and W80 and W84[53] for cruise missiles. In that way, the failure of one warhead type would not compel the withdrawal of an entire class of delivery systems. Still others insure against an inability by NNSA to maintain the stockpile with LEP. While all units of a given warhead type age at the same rate, individual units differ slightly, so may fail at different times or for different reasons.

In the view of DOD and NNSA, RRW would permit a reduction in warhead numbers. Current warheads could be replaced with fewer warheads designed, under RRW, to provide higher confidence in long-term sustainability. RRW would also be linked to a production complex that could manufacture at least small numbers of warheads to respond to new military requirements, permitting a further reduction in stockpiled warheads.

RRW supporters believe that RRW creates an additional path, beyond that offered by LEP, for increasing confidence in warheads. They state that, under LEP's approach of minimizing changes to the nuclear explosive package (NEP), problems can only be resolved by attempting to reduce uncertainties through technical analyses, while RRW also provides the option of increasing margins by redesigning components to compensate for uncertainties.[54]

Skeptics endorse stockpile reductions, but would question the need for RRW to meet this goal. They argue that other means can maintain confidence in warheads. For example, tritium gas, which is used to boost a weapon's yield (see Appendix), decays radioactively, so changing a weapon's tritium more frequently could compensate for uncertainties introduced by slight changes in weapon components

[53] The W84 is not in the active stockpile.

[54] The weapons labs are developing a technique, quantification of margins and uncertainties (QMU), to evaluate how changes affect weapon performance. The idea is to identify key segments of a weapon's performance (e.g., high explosive detonation), the minimum and maximum values required for each segment to perform as intended, the range of uncertainty associated with those values, and the design margins. Under QMU, the labs could have confidence in the warhead if margin exceeds uncertainty at each segment. QMU could be used with LEP or RRW. For more on QMU, see David Sharp and Merri Wood-Schultz, "QMU and Nuclear Weapons Certification: What's under the Hood," *Los Alamos Science*, no. 28, 2003, pp. 47-53; and D.H. Sharp, T.C. Wallstrom, and M.M. Wood-Schultz, *Physics Package Confidence: 'ONE' vs. '1.0,'* NEDPC [Nuclear Explosives Design Physics Conference] 2003, LAUR-04-0496.

under LEP.[55] This change can be made under LEP with no impact to the NEP. Skeptics also point out that RRW would not address some reasons given for a reserve stockpile, so that RRW by itself would not permit large reductions.

RRW supporters agree that changing tritium more frequently could forestall some problems, but note that so doing cannot solve others. For example, a slight asymmetry in the implosion wave might cause the primary to fail, or a failure of the radiation case would prevent the secondary from detonating.

Possible Questions for NNSA. *Warhead Reductions:* President Bush has said, "I am committed to achieving a credible deterrent with the lowest possible number of nuclear weapons consistent with our national security needs ..."[56] Ambassador Brooks indicated that RRW could help meet this goal.[57] What fraction of nondeployed warheads could be eliminated from the stockpile under RRW? How would RRW would permit this reduction? What changes would have to be made, such as streamlining the nuclear weapons complex or rebuilding warheads, under RRW to permit such reductions? What is the schedule for such reductions? If no schedule is available, when might it be? Would DOD find it acceptable to replace the current nondeployed stockpile with fewer RRW warheads rather than replacing existing warheads unit for unit with RRW warheads?

Possible Questions for Skeptics. *Tritium and Warhead Reductions:* Improving warheads' tritium supply to compensate for any erosion of confidence addresses only one problem. Others unrelated to tritium can reduce confidence as well. To what extent would improvements to tritium supply, by themselves, increase confidence enough to permit a reduction in warhead numbers? What would be the basis for this judgment?

Will RRW Save Money? Supporters claim that RRW would save money for the following reasons. Using fewer hazardous materials in components and production processes would reduce the cost of handling, worker and environmental protection, and waste disposal. Components designed for ease of production could be produced with less equipment, in less time, and on less floor space. Components less sensitive to minor variations in dimensions and materials would have fewer

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[55] "In certain cases, slight changes in the attributes of a nuclear weapons component, such as those introduced by using new technologies, can be rendered unimportant by increasing the margin of performance of the weapon. By margin of performance, we mean the difference in primary yield which is expected from a normal weapon and the minimum primary yield which will drive the secondary to essentially full yield. The margin available to a specific weapon changes with time and circumstances, notably because primary yield is so sensitively dependent on the amount of tritium available in the gas system. ... There are various means to enhance the margin without resorting to underground tests ... But it seems clear that the most significant opportunity to enhance margin lies in the gas supply system. ... one obvious means is to shorten the tritium refill cycle so that large excursions in the amount of tritium do not occur." Drell, Jeanloz, et al., *Remanufacture*, p. 23-24.

[56] President George W. Bush, Remarks by the President to Students and Faculty at National Defense University, Fort Lesley J. McNair, Washington, D.C., May 1, 2001.

[57] Brooks statement to Senate Armed Services Committee, Apr. 4, 2005, p. 6.

production units rejected, reducing the waste stream and effectively increasing capacity. Use of more advanced warhead use-control features would permit a reduction in the cost of physical security. Increasing warhead safety would reduce the risk of plutonium dispersal in a fire, and the resulting cost. Reducing stockpile size would lower security and maintenance expenses.

Skeptics favor holding down costs, but not at the expense of confidence in the stockpile. They place more confidence in LEP, and would rather use it even if it costs more than RRW. They also anticipate that RRW would entail high transition costs for development of warhead components and production processes, construction of new nuclear weapons complex facilities, and modification of large numbers of warheads. Posited savings from RRW in operations and maintenance, corrected for inflation, would have to exceed these up-front investment costs for the cost argument to be valid. With RRW at a preliminary stage, skeptics doubt that RRW supporters have nearly enough data to make cost comparisons.

Possible Questions for NNSA. *Cost:* Ambassador Brooks has stated that he thinks RRW would save money.[58] Implementing RRW would entail large investments to develop warheads using RRW, revise the nuclear weapons complex, produce perhaps thousands of warheads designed with RRW, decontaminate and decommission existing nuclear weapons complex facilities, and eliminate existing warheads. At the same time, a smaller complex, more efficient production, simpler maintenance, and longer intervals for major overhauls of warheads could yield long-term savings. What is the basis for claiming that the long-term savings would outweigh the investment costs? Counting costs beginning now, how many years would it take before investment and operating costs for RRW were less than those for LEP? If no answer is currently available because of limited data and analysis, when does NNSA anticipate that the program will have advanced enough to provide an answer?

Possible Questions for Skeptics. *Cost:* RRW will entail substantial investment costs, but once the investment is made operating costs should, by design, be low. In contrast, LEP, over time, is likely to incur substantial and rising operating costs, as it becomes ever more difficult to maintain weapons using obsolete technologies and methods. Is there a basis for believing that LEP's operating costs will not rise? Or that LEP's costs over the next, say, three decades will be less than those of RRW?

How Might RRW Affect the Nuclear Weapons Complex? A responsive infrastructure, including the nuclear weapons complex, is an element of the New Triad.[59] Responsiveness appears to include (1) flexibility, the ability to switch rapidly from work on one warhead type to work on another in case a defect is found that requires a prompt fix; (2) timeliness, the ability to modify warheads or make new-design warheads if needed in time to respond to potential threats, if called for by DOD; and (3) capacity adequate to make fixes in a reasonable time to a warhead

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[58] Ibid.

[59] Crouch, Special Briefing on the Nuclear Posture Review, Jan. 9, 2002.

type with many deployed units, or so that it could work on several warhead types simultaneously.

A responsive infrastructure, RRW supporters believe, requires new-design components. Components that are designed for ease of manufacture and that minimize the use of hazardous materials would permit the plants to use simpler production processes and produce at a faster rate. Conversely, by increasing confidence, RRW could enable DOD to shift its hedge against potential weapon problems from maintaining many inactive warheads to a more responsive infrastructure, thereby reducing the number of nondeployed warheads and the size of the complex needed to support the stockpile.

Skeptics would question whether an LEP infrastructure would be much less responsive than an RRW infrastructure. New-design NEP components fully supportable by nuclear test data could be done under LEP or RRW. The remaining subset of components, new-design NEP components not fully supported by test data, would involve considerable equipment and skill to produce even under RRW. Worse, such components might introduce problems, and correcting them would absorb much of the capacity of the infrastructure, reducing its responsiveness. Finally, responsiveness can be gained in ways other than component design, such as by investment in equipment, facilities, and R&D on manufacturing. Skeptics do not oppose all manufacturing improvements. Some improvements could produce components to tighter tolerances, reducing variations that might raise questions about reliability. Skeptics see a smaller stockpile as the best way to assure responsiveness by easing the burden on the production complex.

Skeptics may find the nuclear weapons complex envisioned by NNSA Administrator Brooks under RRW to be troubling:

> Establishing a responsive nuclear infrastructure will provide opportunities for additional stockpile reductions because we can rely less on the stockpile and more on infrastructure (i.e., ability to produce or repair warheads in sufficient quantity in a timely way) in responding to technical failures or new or emerging threats.[60]
>
> If we can establish a responsive infrastructure and demonstrate we can produce replacement warheads on the same time scale in which geopolitical threats emerge — and if we can demonstrate that we can respond quickly to technical problems, then I believe we can go much further in reducing nondeployed warheads in order to meet the President's stated vision of the smallest stockpile consistent with our nation's security requirements.[61]

Skeptics take these statements as evidence that RRW would entail a substantial production capacity and the ability to design weapons and start production quickly, thereby enabling the buildup of a larger stockpile if desired. They believe that some manufacturing processes could be upgraded under LEP, and reject the implication

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[60] Brooks statement to Senate Armed Services Committee, Apr. 4, 2005, p. 3.

[61] Senate Armed Services Committee hearing, *Strategic Forces/Nuclear Weapons*, Apr. 4, 2005.

that only RRW could deliver a more efficient and responsive complex to support a smaller stockpile.

RRW advocates, however, maintain that the United States needs a nuclear weapons complex as Ambassador Brooks described because it addresses contingencies that could well arise. The United States may need to (1) design and produce new or modified warheads quickly to meet new threats; (2) rebuild several warhead types at the same time; (3) conduct a large-scale, rapid rebuild to correct a defect in a type of warhead deployed in large numbers, and (4) rebuild a smaller stockpile on a continuing basis to avoid issues that could cause uncertainty in performance. Substantial capacity is needed to meet any of these goals, let alone all of them simultaneously. However, they argue that this capacity does not mean that the United States will build a large stockpile; the President and Congress would decide on stockpile size.

Possible Questions for NNSA.

Capacity. As noted, Ambassador Brooks has implied that a new nuclear weapons complex might need to be able to produce warheads at a substantial rate. What capacity does NNSA envision? Transforming the nuclear weapons infrastructure could cost many billions of dollars. Could we attain the needed capacity by using that money to upgrade the existing infrastructure under LEP?

Infrastructure Responsiveness. Ambassador Brooks saw "a responsive infrastructure as essential to reducing total stockpile numbers and associated costs."[62] Why is the current infrastructure not responsive? What steps would make it sufficiently responsive, and what would they cost? Would the savings from reducing stockpile numbers outweigh the costs of building a responsive infrastructure? Could the United States secure sufficient responsiveness at a fraction of the RRW investment cost by upgrading the existing nuclear weapons infrastructure?

Training. Ambassador Brooks has noted, "We are losing expertise" because this nation has not fielded a new warhead in 20 years or modified one in 10 years, yet current weapons staff whose skills were sharpened by nuclear testing are retiring.[63] Brooks fears that if training "is disconnected from real design work that leads to engineered systems," the next generation may "understand the theory, but not the practice, of warhead development," which could threaten future ability to maintain the stockpile. What are the advantages of training designers using RRW rather than LEP?

Possible Questions for skeptics. *RRW and Beyond:* Ambassador Brooks views RRW as a key to transforming the nuclear weapons enterprise.[64] It would support a new stockpile, permit a smaller stockpile and greater confidence in its long-term sustainability, permit a new nuclear weapons complex, reduce costs, and reduce

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[62] Brooks statement to Senate Armed Services Committee, Apr. 4, 2005, p. 5.

[63] Ibid.

[64] Ibid.

the prospect of nuclear testing, to name a few. Can this view be justified? Are these larger goals unreasonable? Can RRW be the basis for reaching them?

Might RRW Undermine U.S. Nonproliferation Efforts? Skeptics oppose RRW to the extent that it could entail a substantial production capacity, facilitates the development of weapons with new military capabilities, or leads to testing. They are concerned that a program of that sort may appear to run counter to the U.S. commitment in Article VI of the Nuclear Nonproliferation Treaty (NPT) to "pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament ..." Further, a statement by China, France, Russia, the United Kingdom, and the United States to the 2000 NPT Review Conference reiterated "our unequivocal commitment to the ultimate goals of a complete elimination of nuclear weapons ..."[65] In this view, reaffirming the value of nuclear weapons through programs such as RRW would make it harder for the United States to achieve its nonproliferation objectives diplomatically. Member states of the NPT, meeting in New York in May 2005 to review treaty implementation, have criticized the United States, though not by name, for nuclear weapon programs, which they see as inconsistent with Article VI of the treaty.[66]

RRW's supporters counter that RRW will increase confidence in the reliability of weapons and in the ability to certify them over the long term. As a result, RRW will reduce the probability that the United States will resume nuclear testing and will permit a substantial reduction in the U.S. nuclear stockpile, both of which could have a positive effect on nonproliferation. In addition, some may take the view that an RRW program that facilitated the development of nuclear weapons with new military missions could help dampen proliferation by strengthening deterrence.

Possible Questions for NNSA.

Capacity and the NPT. In Article VI of the NPT, the parties agreed to negotiate toward nuclear disarmament. The parties to the treaty met at U.N. Headquarters in May 2005 for a five-year review of the NPT; some participants criticized U.S. nuclear weapons programs and policies as running counter to Article VI. How does NNSA square a new nuclear weapons infrastructure that could produce substantial numbers of new-design replacement warheads quickly with Article VI?

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[65] Statement by the Delegations of France, the People's Republic of China, the Russian Federation, the United Kingdom of Great Britain and Northern Ireland, and the United States of America, introduced in *Statement to the 2000 NPT Review Conference* by H.E. Hubert de la Fortelle on behalf of the U.N. permanent five nuclear weapon states, May 1, 2000, available at [http://www.ceip.org/programs/npp/npt2000p5.htm].

[66] See, for example, the statement of Ambassador Wernfried Koeffler, Head of Delegation, Austria, to the 2005 NPT Review Conference, "Our concern that nuclear weapons are still central to strategic planning is increased by reports of intentions to develop new nuclear weapons or alter their design for new uses. Even the affirmation that only concepts are being studied is not reassuring," p. 4.

Sustainability and the NPT. RRW warheads would, by design, be easier to maintain over the long term. Other nations might infer from the replacement of the current stockpile with RRW warheads that the United States is preparing to retain nuclear weapons for the indefinite future, and might view that action as inconsistent with nuclear disarmament. On the other hand, Article VI calls for negotiations for effective measures relating to nuclear disarmament, and it could be argued that a longer-lived stockpile has no bearing on the course of any such negotiations. What is NNSA's view on the relationship, if any, between stockpile sustainability and NPT obligations?

Possible Questions for Skeptics. *RRW and Nuclear Proliferation:* An argument against RRW is that, by replacing the current stockpile with thousands of warheads designed to be more sustainable over the very long term, and replacing the current nuclear weapons complex with a new complex designed to sustain RRW warheads, other nations may infer that the United States plans to keep its warheads indefinitely. That could be viewed as contradicting U.S. commitments under Article VI of the NPT. On the other hand, it could be argued that the United States must maintain its warheads, that RRW is a better way than LEP to do this, and that a decision to eliminate U.S. warheads is a separate debate from RRW. How may RRW affect U.S. nuclear nonproliferation efforts?

Might LEP or RRW Lead to Nuclear Testing? RRW's supporters and skeptics both prefer to avoid nuclear testing. The Administration has continued the nuclear test moratorium, though it has asserted it would test if required.[67] That has not been needed because DOD has no requirement for nuclear weapons with new or modified capabilities, and because the Secretaries of Defense and Energy have been able to certify the stockpile without testing.[68] Because the Administration does not support the Comprehensive Test Ban Treaty,[69] it has not spelled out arguments against testing. It could be, however, that part of the rationale for avoiding testing is political, as testing could cause massive protests domestically and internationally. Further, most nations would likely view resumed U.S. testing as a clear breach of U.S. obligations on behalf of nuclear disarmament and could lead to the unraveling of the nuclear nonproliferation regime and to testing by others.

NNSA argues that RRW would reduce the need for testing. Ambassador Brooks has said, "not only is the reliable replacement warhead program not designed to foster a return to nuclear testing, it is probably our best hedge against the need

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[67] Brooks testified, "We believe the nation must be prepared to carry out an underground nuclear test in the event of unforeseen problems that can't be resolved by other means." U.S. Congress, House Committee on Armed Services, Strategic Forces Subcommittee, *FY2006 budget request from the Department of Energy on Atomic Energy Defense Activities*, hearing, Mar. 2, 2005.

[68] Senate Armed Services Committee hearing, *Strategic Forces/Nuclear Weapons*, Apr. 4, 2005.

[69] The treaty would ban nuclear explosions. It was opened for signature in 1996 but has not entered into force. The U.S. Senate rejected it in 1999. See CRS Issue Brief IB92099, Nuclear Weapons: Comprehensive Test Ban Treaty, by Jonathan Medalia.

sometime in the future to be faced with the question of a return."[70] Components could be designed to be less sensitive to minor changes in materials and processes and to permit looser tolerances. As a result, uncertainties that might prompt a nuclear test on current weapons might be acceptable with RRW components.

Skeptics endorse a continuation of the nuclear test moratorium, but fear that changes under RRW that NNSA claims would reduce the need for testing could actually increase it. Small changes to the NEP that were within the parameters validated by past nuclear tests could be done under LEP. It is as yet unclear if changes made under RRW would be within these parameters; changes of greater magnitude could undermine confidence in the warhead and lead to testing.

Possible Questions for NNSA. *RRW and Reduced Nuclear Testing:* Ambassador Brooks has anticipated that RRW will reduce the need for nuclear testing.[71] How will RRW achieve this goal? Does NNSA have plans for how it might respond if severe design flaws were discovered in RRW weapons? Would new-design components stay within the design parameters validated by past nuclear tests? What would be the process for validating new design components that are not within design parameters validated by previous tests without a resort to testing?

Possible Questions for Skeptics. *LEP and Increased Nuclear Testing:* RRW supporters fear that LEP could lead to an accretion of small changes that would undermine confidence in a warhead, ultimately requiring nuclear testing. Is that a cause for concern? RRW supporters claim that RRW components could be designed to be less sensitive to minor variations arising during production. On the other hand, RRW would introduce larger-scale changes into components than would LEP. On balance, is RRW more or less likely to lead to nuclear testing than is LEP? Why?

Might RRW Enable an Increase In Inherent Warhead Security? There are two aspects to warhead security — access control and use control. The first is a matter of physical protection and is the responsibility of DOD or DOE. The second is ensuring that anyone who gains unauthorized access to a warhead is not able to detonate it. In the wake of the 9/11 attacks, both have increased in importance. For example, NNSA's FY2002 request for Safeguards and Security was $448.9 million, while the FY2006 request is $708.5 million. Use control has always been part of warhead design. In the earliest days, fissile materials were reportedly kept separate from bomb casings, in part for control.[72] For many years, weapons have used permissive action links, which require a code to activate the weapon. Now, with a higher threat of terrorist attack, RRW supporters claim that further modifications to the weapon for use control are in order. Ambassador Brooks, discussing RRW, has stated:

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[70] Senate Armed Services Committee hearing, *Strategic Forces/Nuclear Weapons*, Apr. 4, 2005

[71] Brooks statement to Senate Armed Services Committee, Apr. 4, 2005, p. 5.

[72] Thomas Cochran, William Arkin, and Milton Hoenig, *Nuclear Weapons Databook, Volume I, U.S. Nuclear Forces and Capabilities*, (Cambridge, MA: Ballinger, 1984), p. 6. See also ibid., pp. 30-31.

> We now must consider the distinct possibility of well-armed and competent terrorist suicide teams seeking to gain access to a warhead in order to detonate it in place. This has driven our site security posture from one of "containment and recovery" of stolen warheads to one of "denial of any access" to warheads. This change has dramatically increased security costs for "gates, guns, guards" at our nuclear weapons sites. If we were designing the stockpile today, we would apply new technologies and approaches to warhead-level use control as a means to reduce physical security costs.[73]

Skeptics say that physical security and existing use-control features are quite sufficient to protect warheads against theft by terrorists. The record in this regard is exceptional. Warhead vulnerability has been reduced since the end of the Cold War by withdrawing thousands of tactical nuclear weapons from Europe and from Navy ships, and by reducing the number of deployed strategic nuclear warheads sharply. General James Cartwright, USMC, Commander, U.S. Strategic Command, said, "I am comfortable that we have the [nuclear] weapons protected and that we are moving to a posture that will improve that protection in light of the changing threat."[74] Skeptics also question if DOE and DOD would reduce physical security even if enhanced-security warheads were deployed. At any rate, in this view, Russian nuclear warheads and materials are at much higher risk, so U.S. programs to secure them would be a better investment than improvements to U.S. warheads.

Skeptics question the merits of redesigning warheads to incorporate new use-control features. So doing might reduce confidence in the warheads, at high cost, and for little potential benefit. According to Robert Peurifoy, a former Vice President at Sandia National Laboratories, "Use control features were originally intended to delay the unauthorized use of a nuclear weapon by friendly forces, including U.S. custodians. It has now magically transformed in the minds of many to the prevention of unauthorized use by terrorists. I don't believe this can be done."[75]

Possible Questions for NNSA. *Physical Security:* Ambassador Brooks has stated, "We now must consider the distinct possibility of well-armed and competent terrorist suicide teams seeking to gain access to a warhead in order to detonate it in place."[76] How likely is this threat? Is it a threat mainly to the few U.S. warheads located overseas? If so, would it be militarily acceptable to withdraw those warheads to the United States? Is it a threat to warheads in this nation? Would permissive action links prevent terrorists from operating a warhead they seized? Could the United States achieve a given level of security at less cost by adding physical security (guards, gates, guns) rather than by rebuilding the stockpile? If NNSA built enhanced-security warheads through RRW, would it and DOD reduce physical security? Would the gain in security from redesign and replacement outweigh the technical risk? What plans does NNSA have to incorporate enhanced security features on RRW warheads? Could it backfit some security enhancements

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[73] Brooks statement to Senate Armed Services Committee, Apr. 4, 2005, p. 4.

[74] Testimony at Senate Armed Services Committee hearing, *Strategic Forces/Nuclear Weapons*, April 4, 2005.

[75] E-mail from Robert Peurifoy to the author, Mar. 26, 2005.

[76] Brooks statement to Senate Armed Services Committee, Apr. 4, 2005, p. 4.

onto existing warheads? Might we compare the cost and effectiveness of increasing security by building RRW warheads, by retrofitting existing warheads, and by increasing physical security?

Possible Questions for Skeptics. *RRW and Use Control:* An argument for RRW is that that program would let the labs incorporate enhanced use-control features into modified weapons to reduce the risk that terrorists could seize weapons and detonate them in place. The argument continues that these new designs would let NNSA and DOD reduce the cost of guns, gates, and guards. Are current use-control features adequate? Is enhanced use control a valid argument for RRW? Would designing such features into a warhead significantly increase the technical risk of the design? Is it realistic to expect that warheads with enhanced use control would permit NNSA and DOD to reduce physical security costs?

Might RRW Enable an Increase In Warhead Safety? While the United States has taken steps to increase the safety of its warheads against lightning, fire, impact, etc., not all warhead types incorporate all existing safety features. Some use conventional high explosive (CHE) rather than insensitive high explosive (IHE); the latter will not detonate in various accidents, while the former can, possibly scattering plutonium. Some warheads lack fire-resistant pits, which are designed to increase the time and temperature that a warhead exposed to fire will contain plutonium.

RRW advocates make the following argument. The technology of current warheads is frozen in the 1980s, and LEP perpetuates that technology. The only way to move beyond it is to use new-design components that incorporate current advances. Since the United States will retain its stockpile for an indefinite time, the cost of the safety gains would be amortized over many years. To enhance safety, the RRW program may consider ways to modify warhead components, including those in the NEP, to increase fire resistance.

Skeptics believe that warheads are quite safe, and that safety has improved over the years thanks to safer designs and improved handling procedures. They are concerned that some safety changes to the NEP would go beyond what is supported by nuclear test data and could jeopardize reliability. For example, it is critically important to the performance of the primary, and thus of the secondary, that the pit implode with reasonable symmetry. A vast amount of effort has gone into developing such pits and determining the bounds of "reasonable." Because IHE is significantly less energetic than CHE, more IHE must be used to obtain the same implosive force. But using a larger amount of less energetic material would alter the implosion wave, necessitating other adjustments in order to use the same pit.

Some safety-related changes would, skeptics believe, offer little value. For example, the W88 or W76 warheads for Trident missiles could be candidates for backfitting with IHE. They use CHE because the Navy sought to maximize yield-to-weight. Using IHE on the W88 would have reduced range by 10 percent, or warhead yield by "a modest amount," or the number of warheads the missile could carry from eight to seven.[77] A 1990 study expressed concern about the safety of CHE.[78] Sidney Drell, the panel chairman and lead author of the study, however, stated in 2005 that further studies revealed that the CHE in the W88 would not detonate even if subjected to a harder knock than was realized in 1990, and that little would be gained by substituting IHE in the warhead because the missile itself used a very energetic propellant that is relatively easy to detonate. An accident that caused the propellant to detonate could break apart the warheads, scattering plutonium, regardless of the explosive used on the warhead. Unless the missile was redesigned to use a less energetic propellant, which would be very costly, replacing CHE with IHE in the warheads would produce little gain in safety. Further, because CHE and IHE are very different in terms of energy density, burn characteristics, etc., Drell believes that there is no way that IHE could be substituted for CHE without nuclear testing.[79]

Might RRW Reduce Adverse Consequences of Aging? RRW supporters hold that the effects of aging can be reduced. Materials less sensitive to aging can be used, processes can be better characterized so they can be repeated more precisely, and new components can be designed to use such materials and processes.

Skeptics feel that RRW advocates have overstated the problem and minimized the ability of LEP to cope with it. They feel that LEP can continue to correct aging problems, as it has for many years. They hold that changes in materials must be done with extensive study to determine if the material will work as did the original, but assert that distinguishing the "large" changes of RRW from the "small" changes made under LEP is largely a matter of semantics as long as the changes are made under the condition that they will not require the resumption of nuclear testing.

Might RRW Enable Reduced Use of Hazardous Materials? Warheads and their manufacture use many hazardous materials (hazmat). Hazmat require special handling of materials and equipment: glove boxes, other layers of containment, filtration of air vented into the atmosphere, disposition of scrap material and contaminated solvents, and compliance with numerous environmental and safety regulations. Regulations now ban some industrial solvents that were used to produce current warheads. Minimizing or eliminating hazmat would produce benefits for cost, ease of production, and worker safety. During the Cold War, warheads used these materials to save weight, or because a particular material was the standard way to solve a design problem. RRW advocates believe that advances in weapons knowledge over the past quarter-century and establishing hazmat reduction as a design goal make it possible to design components that minimize hazmat usage.

Skeptics agree that reduction of hazmat is a worthy objective, but question if it is worth the costs and risks. Redesign, validation, and production of components would require extensive testing and study, and would run the risk that a different

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[77] U.S. Congress,. House Committee on Armed Services, *Report of the Panel on Nuclear Weapons Safety,* Committee Print No. 14, 101st Congress, 2nd Session, p. 28. By Sidney Drell, Chairman, John Foster, Jr., and Charles Townes.

[78] Ibid., p. 32.

[79] Information provided by Sidney Drell to the author, Mar. 16, May 3, and May 4, 2005.

material, especially in the NEP, could impair reliability. New materials might impair reliability if they decomposed in an unanticipated manner. Existing components and materials have become increasingly well characterized. That knowledge base reduces the advantage of eliminating hazmat. Some skeptics would retain existing components, materials, and processes to the extent possible, even if that meant retaining hazmat, on grounds that that is the surest way to retain confidence in reliability. They would consider having dedicated production lines if needed to produce some materials and would consider filing for waivers to hazmat regulations if needed to continue using such materials. Others would consider redesign of some non-NEP components to eliminate hazmat if it could clearly be demonstrated, on a case by case basis, that the benefits were substantial and the uncertainties were minimal.

Policy Options for Congress

RRW is a new program with no specific, tangible product yet defined. In deciding how to proceed on RRW, Congress has a number of options available to it.

Decide Whether and How to Proceed. As with any program, Congress could choose to continue RRW as requested or terminate it. Several options exist between those extremes. Congress could allow NNSA to pursue RRW and LEP as complementary programs. It could limit RRW to modification of components and bar the program from considering new-design warheads. It could bar RRW from making warhead changes that would increase military capability or that could reasonably be expected to lead to nuclear testing. It could delay a decision on such choices pending the outcome of the FY2005-FY2006 RRW study.

Clarify the Scope of RRW. Because RRW is a new program, its scope is in the process of being defined. Congress might wish to help focus and shape the program by asking NNSA to answer a number of questions to better define it.

- What design changes does NNSA envision making in warhead components with RRW that could not be made with LEP?
- If NNSA proceeds with LEPs for W76 and W80, would that truly preclude transformation of the nuclear weapons complex for decades? If so, when must a choice between LEP and RRW be made?
- Will RRW involve the construction of one or more new sites for the nuclear weapons complex outside existing sites? Will it involve construction of new facilities at existing sites? What upgrades to facilities are envisioned to foster a responsive infrastructure?
- Will RRW lead to the closing of any existing nuclear weapons complex sites?

Impose Legislative Requirements. Congress may also wish to define the bounds of RRW legislatively by requiring that

- RRW components stay within the design parameters validated by nuclear testing.
- RRW not be used to enhance military capabilities or provide for new military missions.
- The number of non-deployed warheads be significantly reduced if RRW proceeds.

Require a Plan and Budget for RRW. It may be too early to expect NNSA to provide a detailed program plan and a rough budget estimate for the FY2006 budget cycle because RRW did not exist as a funded program until December 2004. Congress may, however, wish to require NNSA to provide a five-year budget and plan with its FY2007 budget submission.

Congressional Action on the FY2006 RRW Request

The House Appropriations Committee reported the FY2006 Energy and Water Development Appropriations Bill, H.R. 2419, on May 18, 2005 (H.Rept. 109-86). The bill passed the House, 416-13, on May 24 with no amendments to the Weapons Activities section. In its report, the committee offered a "qualified endorsement" of RRW "contingent on the intent of the program being solely to meet the current military characteristics and requirements of the existing stockpile." (p. 128) It did not endorse RRW if it produces new weapons for new military missions. (p. 128)

The committee saw RRW as part of a new Sustainable Stockpile Initiative, under which DOE would "develop an integrated RRW implementation plan that challenges the [nuclear weapons] complex to produce a RRW certifiable design while implementing an accelerated warhead dismantlement program and an infrastructure reconfiguration proposal that maximizes special nuclear material [essentially, highly enriched uranium and weapons-grade plutonium] consolidation." (p. 128)

The committee focused on RRW throughout its discussion of Weapons Activities, linked RRW to many Weapons Activities programs, and used the potential of RRW as the rationale to reduce or delay several requested programs. Its many actions and statements on RRW include the following:

- "The RRW weapon will be designed for ease of manufacturing, maintenance, dismantlement, and certification without nuclear testing, allowing the NNSA to transition the weapons complex away from a large, expensive Cold War relic into a smaller, more efficient modern complex. A more reliable replacement warhead will allow long-term savings by phasing out the multiple redundant Cold War warhead designs that require maintaining multiple obsolete production technologies to maintain the older warheads." (p. 128)

- "The Committee directs the Secretary of Energy to establish a Federal Advisory Committee on the Reliable Replacement Warhead initiative ..." (p. 128)

- A rebaselined LEP, an RRW program plan, and a dismantlement plan would provide "reliable nuclear deterrence" with a stockpile after 2025 that is significantly smaller than the stockpile level planned for 2012. As a result, "the current Life Extension Plans will be scoped back to lower levels and the resources will be redeployed to support the Sustainable Stockpile Initiative." Accordingly, the committee recommended reducing the budget request for Directed Stockpile Work, a major category of Weapons Activities that directly supports weapons in the stockpile, by $137.3 million to $1,283.7 million. (p. 129)

- The committee recommended increasing RRW funding from $9.4 million to $25.0 million "to accelerate the planning effort to initiative a competition between the NNSA weapons laboratories to develop the design for the RRW re-engineered and remanufactured warhead." (p. 130)

- The committee recommended eliminating the $4.0 million requested to study the Robust Nuclear Earth Penetrator, in part because it "threatens Congressional and public support for sustainable stockpile initiatives that will actually provide long-term security and deterrent value for the Nation." (p. 131)

- Test Readiness is a program to enable the resumption of nuclear testing at Nevada Test Site should that be deemed necessary. Last year, the committee opposed a move to reduce the test readiness posture (the time between a presidential decision to test and the conduct of the test) from 24 to 18 months, this year, it added RRW to the rationale against an 18-month posture: "The initiation of the Reliable Replacement Warhead (RRW) program designed to provide for the continuance of the existing moratorium on underground nuclear testing by insuring the long-term reliability of the nuclear weapons stockpile obviates any reason to move to a provocative 18-month test readiness posture." (p. 132) Accordingly, it recommended reducing Test Readiness funds from $25.0 million to $15.0 million.

- The committee noted that "Congressional testimony by NNSA officials is beginning to erode the confidence of the Committee that the Science-based Stockpile Stewardship is performing as advertised." Accordingly, it "redirects ASCI [Advanced Simulation and Computing] funding to maintain current life extension production capabilities pending the initiation of the Reliable Replacement Warhead program" and recommended reducing funding from $660.8 million to $500.8 million. (pp. 133-134)

- The committee recommended eliminating the $7.7 million requested for the Modern Pit Facility (see Appendix). It recommended that "NNSA focus its efforts on how best to lengthen the life of the stockpile and minimize the need for an enormously expensive infrastructure facility until the long-term strategy for the physical infrastructure of the weapons complex has incorporated the Reliable Replacement Warhead strategy ...” (p. 134)

- The committee recommended eliminating the $55.0 million requested for construction of the Chemistry and Metallurgy Research Facility Replacement (CMRR) at Los Alamos. “Construction at the CMRR facility should be delayed until the Department [of Energy] determines the long-term plan for developing the responsive infrastructure required to maintain the nation’s existing nuclear stockpile and support replacement production anticipated for the RRW initiative.” (p. 136)

The House Armed Services Committee reported the FY2006 National Defense Authorization Bill, H.R. 1815, on May 20 (H.Rept. 109-89). The bill passed the House, 390-39, on May 25 with no amendments concerning RRW. The committee recommended providing the amount requested for RRW. The report stated: “The committee firmly believes that the nation must ensure that the nuclear stockpile remains reliable, safe, and secure and that national security requires transforming the Cold War-era nuclear complex. Thus, the committee supports the Reliable Replacement Warhead program. To clearly articulate the congressional intent underlying this program authorization, the committee further states the key goals of the program.” (p. 463) In Section 3111 of H.R. 1815, the committee required the Secretary of Energy, in consultation with the Secretary of Defense, to carry out the RRW program, and spelled out its objectives for RRW:

> `(b) Objectives- The objectives of the Reliable Replacement Warhead program shall be —
>
> `(1) to increase the reliability, safety, and security of the United States nuclear weapons stockpile;
>
> `(2) to further reduce the likelihood of the resumption of nuclear testing;
>
> `(3) to remain consistent with basic design parameters by using, to the extent practicable, components that are well understood or are certifiable without the need to resume underground nuclear testing;
>
> `(4) to ensure that the United States develops a nuclear weapons infrastructure that can respond to unforeseen problems, to include the ability to produce replacement warheads that are safer to manufacture, more cost-effective to produce, and less costly to maintain than existing warheads;
>
> `(5) to achieve reductions in the future size of the nuclear weapons stockpile based on increased reliability of the reliable replacement warheads;
>
> `(6) to use the design, certification, and production expertise resident in the nuclear complex to develop reliable replacement components to fulfill current mission requirements of the existing stockpile; and

`(7) to serve as a complement to, and potentially a more cost-effective and reliable long-term replacement for, the current Stockpile Life Extension Programs.'

The committee's report (pp. 464-465) described these objectives in more detail. Section 3111 of H.R. 1815 also required the Nuclear Weapons Council to submit an interim report on RRW by March 1, 2006, and a final report by March 1, 2007. The final report is to: assess characteristics of warheads to replace existing ones; discuss the relationship of RRW within SSP and its impact on LEPs; assess the extent to which RRW, if successful, could lead to a reduction in warhead numbers; discuss RRW design criteria that will minimize the likelihood of nuclear testing; describe the infrastructure needed to support RRW; and summarize how funds will be used.

Of the committee's 28 Democratic members, 23 signed a statement of additional views that was included in the committee report (pp. 511-512). According to the statement, "Democrats are willing to explore the concept of the RRW program, but do not yet embrace it." They felt that, to merit support, RRW must reduce or eliminate the need for nuclear testing, lead to dramatic reductions in the arsenal, avoid introducing new mission or weapon requirements, deemphasize nuclear weapons' military utility, increase nuclear security, and "[lead] to ratification and entry into force of the Comprehensive Test Ban Treaty." On the latter point, they maintained that a successful RRW program should erase the main rationale against the treaty, uncertainty about the reliability of the nuclear arsenal. Therefore, "[w]e believe strongly that ratification of the CTBT [Comprehensive Test Ban Treaty] is the logical end result of a successful RRW program ..."

The Senate Armed Services Committee reported the FY2006 National Defense Authorization Bill, S. 1042, on May 17.[80] It recommended providing the amount requested for RRW. It noted that NNSA Administrator Brooks had presented several goals for RRW in his testimony to the committee on April 4: increasing warhead security and reliability; developing replacement components that can be manufactured more easily, using materials that are more readily available and more environmentally benign; developing replacement components that provide high confidence in warhead safety and reliability; developing these components on a schedule that would reduce the need to conduct a nuclear test to address a reliability problem; reducing the cost and increasing the responsiveness of the infrastructure; and increasing confidence in the stockpile enough to permit reductions in non-deployed warheads. "The committee supports these goals and this modest investment in feasibility studies." It required NNSA's Administrator to submit a report to the congressional defense committees by February 6, 2006, "describing the activities undertaken or planned for any RRW funding in fiscal years 2005, 2006, and 2007." As of July 20, the Senate had not considered the measure.

[80] Material in this paragraph is from U.S. Congress, Senate Committee on Armed Services, *National Defense Authorization Act for Fiscal Year 2006*, report to accompany S. 1042, 109th Congress, 1st Sess., S.Rept. 109-69, (Washington: GPO, 2005), p. 482.

The Senate Appropriations Committee reported H.R. 2419 on June 16.[81] It endorsed RRW and recommended increasing its funding above the FY2006 request.

> The Committee recognizes that RRW is early in its development and will not significantly alter the near-term plans for stockpile support such as LEPs, but NNSA is encouraged to move aggressively to incorporate benefits from RRW into the stockpile as soon as possible.
>
> The Committee recommends $25,351,000 for RRW to accelerate the planning, development and design for a comprehensive RRW strategy that improves the reliability, longevity and certifiability of existing weapons and their components.[82]

The bill passed the Senate, 92-3, on July 1, with no change to the RRW provision.

In sum, Congress has expressed support for RRW in various ways in the FY2006 budget cycle. The House twice voted for bills that contain at least the full amount requested for RRW, both Armed Services Committees recommended fully funding the request, and both Appropriations Committees recommended a sharp increase in RRW funding. The Appropriations and Armed Services Committees saw RRW as a way to achieve a wide range of goals for the nuclear weapons program. At the same time, reflecting uncertainties that surround a new program, these four committees spelled out goals for the program, and both Armed Services Committees required reports on RRW.

Implementing RRW[83]

With Congress, NNSA, and DOD having launched the RRW program, the next step is implementation. How are NNSA and DOD implementing RRW? The Nuclear Weapons Council approved the formation of a DOD/DOE Project Officers' Group, or POG, for the RRW program on March 23, 2005. According to NNSA, the POG is composed of representatives of NNSA, the nuclear weapon labs (Los Alamos, Lawrence Livermore, and Sandia), the Office of the Secretary of Defense, STRATCOM, the Navy, the Air Force, and Lockheed Martin Space Systems Company.[84] There are also observers from the Office of the Chief of Naval Operations, the Defense Threat Reduction Agency, and three nuclear weapon plants

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[81] U.S. Congress, Senate Committee on Armed Services. *Energy and Water Appropriations Bill, 2006,* S.Rept. 109-84, to accompany H.R. 2419. 109th Congress, 1st Sess., 2005.

[82] Ibid., p. 155.

[83] NNSA staff provided most of the information in this section, and lab and plant staff provided some of the information, June and July 2005.

[84] Lockheed Martin Space Systems Company, a subsidiary of Lockheed Martin Corporation, and its predecessor organizations have developed and manufactured all U.S. SLBMs. This company is on the POG to provide expertise on compatibility of candidate SLBM replacement warhead designs with their delivery system, Trident II missiles.

(Kansas City, Pantex, and Y-12).[85] In practice, POGs do not take votes, so members and observers participate on an equal footing. The Nuclear Weapons Council tasked the POG to conduct an 18-month design competition, which started with the first POG meeting in May 2005. According to NNSA, in the competition, two teams — Los Alamos and Sandia New Mexico, and Lawrence Livermore and Sandia California — would each provide warhead designs consistent with RRW program objectives. The council set out the terms of reference for the designs in a memorandum to the POG. DOD requested that the study be done as a competition between the two teams rather than as a collaboration, according to NNSA.

The designs would initially focus on a submarine-launched ballistic missile (SLBM) replacement warhead, NNSA indicates. This is consistent with a statement in a House Armed Services Committee report: "the committee encourages the Department of Defense and the Department of Energy to focus initial Reliable Replacement Warhead efforts on replacement warheads for Submarine Launched Ballistic Missiles."[86] Because of this SLBM focus, the Navy is the POG chair, and the Air Force is co-chair.

In the study competition, the two teams will develop and possibly demonstrate pit fabrication processes, and will assess design of nuclear and nonnuclear components for ease of manufacture, ease of certification, compatibility with military platforms, and enhanced safety and reliability, among other things. The two teams will work closely with the three plants to ensure that the plants can provide components consistent with RRW program objectives, including those on manufacturing and responsive infrastructure, according to plant staff.

Details of the 18-month effort are being developed. According to lab staff, one approach is to look at warheads that could be used on SLBMs and intercontinental ballistic missiles (ICBMs). For example, in this approach, the first warhead produced under RRW (here called RRW-1) would be an SLBM warhead but would potentially be compatible with ICBMs as well, and RRW-2 would be designed as an ICBM warhead but would also be compatible with SLBMs. In this way, the two warheads would be each other's backup: if one failed, the other could be deployed on both missile types. This approach would permit two warhead designs to replace four current warhead types (W76 and W88 for SLBMs, W78 and W87 for ICBMs) now in the stockpile, and would meet objectives set forth in the House Appropriations Committee's energy and water report: "A more reliable replacement warhead will allow long-term savings by phasing out the multiple redundant Cold War warhead designs that require maintaining multiple obsolete production technologies to maintain the older warheads."[87] Further in the future, according to

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[85] The Savannah River Site, another nuclear weapons plant, is not involved in the POG because it does not design warhead components; its role is to supply tritium for warheads.

[86] U.S. Congress, House Committee on Armed Services, *National Defense Authorization Act for Fiscal Year 2006,* H.Rept. 109-89, to accompany H.R. 1815, 109th Cong., 1st Sess., 2005, p. 464.

[87] U.S. Congress, House Committee on Appropriations, *Energy and Water Development Appropriations Bill, 2006,* H.Rept. 109-86, to accompany H.R. 2419, 109th Cong., 1st Sess., (continued...)

lab staff, this approach might be applied to bomber-carried weapons (bombs and air-launched cruise missiles), possibly permitting the replacement of four types of such nuclear weapons (B61 and B83 gravity bombs, and W80 and W84 cruise missile warheads) with two RRW types. However, it is too soon to say if this cross-platform approach will work. It may prove impossible to add another layer of constraints — incorporating design features to enable a warhead to work on two missile- or two bomber-delivered weapon types — and still meet its other requirements.

NNSA provided details on the design selection process. The competing designs are to be completed sometime in 2006, with the exact date under negotiation as of July 2005. The POG will establish weighting factors for design selection. It will review the designs and transmit a recommendation for a design to the Nuclear Weapons Council. Assuming that the council approves the design, the labs and plants would then conduct a detailed design definition and a cost study for the selected design.[88] The POG would then evaluate the results of the design and cost study to establish a recommendation to the Nuclear Weapons Council on whether to proceed further with the design. If the council approves, and if the Administration and Congress decide to proceed, then the labs, working with the plants, and working with DOD to ensure that the warhead is compatible with the Trident II missile,[89] would conduct development engineering (detailed design work) for RRW-1. The Nuclear Weapons Council may select more than one design for a cost study and design definition because different designs might offer different advantages, such as compatibility with ICBMs and SLBMs or ease of manufacture and certification. According to NNSA, only one design would proceed to development engineering. RRW-2, an ICBM replacement warhead, would follow a similar course, and might use one of the designs initiated in the RRW-1 competition.

According to NNSA, DOD would like to have the first production unit of RRW-1 completed around FY2012. Because of the need to continue with life extension programs and until more RRW development work is completed, NNSA estimates that FY2015 may be a more achievable date. NNSA believes that it could meet an accelerated schedule, but at the expense of reprioritizing other planned stockpile stewardship activities.

The three nuclear weapons laboratories (Los Alamos, Livermore, and Sandia) have spelled out the need for a program such as RRW and their view of their role in

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[87] (...continued)
2005, p. 130.

[88] For a description of the phases of development of nuclear weapons other than new ones, such as refurbishments, modernizations, and life extensions, see U.S. Department of Defense and Department of Energy. Nuclear Weapons Council, *Procedural Guideline for the Phase 6.X Process,* Apr. 19, 2000.

[89] The Trident I missile will be phased out around FY2005. (Source: U.S. Strategic Command, Public Affairs, *Fact File: Ballistic Missile Submarines(SSBNs,* Mar. 2004.) That is well before RRW-1 is deployed, so that warhead would be deployed only on Trident II missiles.

that program in a report.[90] In brief, they argue that while LEP is working, there are increasing uncertainties about its ability to sustain the stockpile over the long term, and that a "vision of sustainable warheads with a sustainable [nuclear] enterprise can best be achieved by shifting from a program of warhead refurbishment to one of warhead replacement."[91] While the three plants involved in RRW (Kansas City, Pantex, and Y-12) have not prepared a report on their role in RRW, plant staff indicate that the plants will work with the labs and NNSA to identify options for manufacturing processes and infrastructure transformation, such as steering the labs away from hard-to-manufacture designs. According to NNSA, the plants' input has started because the labs have already provided early design information. The contribution of the plants will change over time as the designs become more mature, at which time the designers would be in a position to accept detailed recommendations on manufacturing from the plants. The results of this work, NNSA states, will be incorporated in the design and cost study. This role of the plants is in keeping with numerous congressional statements that manufacturability and issues that flow from it, such as affordability and reduction of hazardous materials, are central goals of RRW. Pit manufacture is an exception. Absent a pit manufacturing facility, all pit manufacturing development activities for RRW will be done at Livermore and Los Alamos, not at the plants.

The Administration's FY2006 request for RRW is $9.4 million. The National Defense Authorization Bill (H.R. 1815) as passed by the House included that amount, as did that bill (S. 1042) as reported by the Senate Armed Services Committee. At the same time, the House-passed version of the Energy and Water Development Appropriations Bill (H.R. 2419) included $25.0 million, and the version of H.R. 2419 as passed by the Senate included $25.4 million. When a spending amount is at issue between an authorization act and an appropriations act, the amount specified in the appropriations act typically prevails.

The House Appropriations Committee directed that "[t]he additional funds are provided to accelerate the planning effort to initiate a competition between the NNSA weapons laboratories to develop the design for the RRW re-engineered and remanufactured warhead."[92] The Senate Appropriations Committee report also recommended the additional funds to accelerate RRW, as noted below. If the FY2006 appropriation is around $25 million, NNSA and lab staff members state that the added funds would accelerate progress in determining RRW's feasibility in the 18-month study. Specifically, the funds would enable more nonnuclear experiments and computer models, investigation of a broader range of design options for each candidate warhead, more confidence in the designs, more mature designs, and more development and demonstration of manufacturing processes. Regarding the latter point, NNSA said that it might allocate some of the added funds to Los Alamos and Livermore to help demonstrate pit manufacturing processes, and some to the plants

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[90] K. Henry O'Brien et al., *Sustaining the Nuclear Enterprise — A New Approach,* published jointly by Lawrence Livermore, Los Alamos, and Sandia National Laboratories, UCRL-AR-212442, May 20, 2005.

[91] Ibid., p. 3.

[92] House Appropriations Committee, *Energy and Water Development Appropriations Bill, 2006,* p. 132.

if needed to evaluate methods to manufacture components more easily and at lower cost. Decisions by NNSA on allocating FY2006 RRW funds will have to wait for a final appropriations bill to be signed into law.

RRW envisions a thorough reordering of priorities in weapon design, and envisions making many tradeoffs to achieve these new priorities. One tradeoff entails a possible dilemma that has been created through what may prove to be incompatible requirements for RRW. Congress has directed that RRW should improve existing weapons and not develop new ones:

> The [Senate Appropriations] Committee recommends $25,351,000 for RRW to accelerate the planning, development and design for a comprehensive RRW strategy that improves the reliability, longevity, and certifiability of *existing weapons and their components.*[93]

> The [House Appropriations] Committee's qualified endorsement of the RRW initiative is based on the assumption that a replacement weapon will be designed only as a re-engineered and remanufactured warhead for an existing weapon system in the stockpile. The Committee does not endorse the RRW concept as the beginning of a new production program intended to produce new warhead designs or produce new weapons for any military mission beyond the current deterrent requirements. The Committee's support of the RRW concept is contingent on the intent of the program being solely to meet the current military characteristics and requirements of the existing stockpile.[94]

H.R. 1815, the FY2006 National Defense Authorization Bill as passed by the House, contains the following passage on RRW in Section 3111:

> Program Required- The Secretary of Energy, in consultation with the Secretary of Defense, shall carry out a program, to be known as the Reliable Replacement Warhead program, to develop reliable replacement *components* that are producible and certifiable for the *existing* nuclear weapons stockpile. [emphasis added]

At the same time, Congress has spelled out many benefits it hopes to gain from RRW if the concept works as NNSA anticipates, such as lower cost, enhanced ability to manufacture and certify warheads, reduced use of hazardous materials, reduced numbers of non-deployed warheads, and restructuring of the nuclear weapons complex.[95]

Yet the labs appear to believe that the path to meeting the many simultaneous requirements needed to achieve these benefits is to design replacement warheads that meet RRW criteria and without the Cold War constraints that were imposed for

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[93] U.S. Congress, Senate Committee on Appropriations, *Energy and Water Development Bill, 2006,* S.Rept. 109-84, to accompany H.R. 2419, 109th Cong., 1st Sess., 2005, p. 155; emphasis added.

[94] House Appropriations Committee, *Energy and Water Development Appropriations Bill, 2006,* p. 130.

[95] For further detail, see "Congressional Action on the FY2006 RRW Request," above.

current designs. According to the tri-lab report, "The goal of this approach [of which RRW is an example] is to achieve a more affordable, sustainable, and responsive enterprise. In order to transform the enterprise in this way, the warhead designs that drive the enterprise must change. Warhead designs can be developed that emphasize manufacturability, certifiability, and increased safety and security, and enable enterprise transformation."[96] In addition, two limits imposed on the design of an RRW are that the warhead offer no new military capability and not require nuclear testing for certification and long-term maintenance. One possible issue for Congress: are new-design replacement warheads with such limits acceptable if that is the only way to obtain RRW's potential advantages?

The seeming dilemma may hinge on one's definition of a "new" warhead, an issue that has been contentious in Congress.[97] While it is much too early to say what design the 18-month study will produce, the design will in all likelihood involve far more than modifying a few components. Design criteria will be much different than those of the Cold War, all nuclear and nonnuclear components of a warhead will be subject to change, tradeoffs between components may be made, and design features of some components may require changes in other components. As a result, a new replacement warhead design may well be the only way to attain the benefits that Congress seeks from the RRW program. Some argue that a new replacement warhead design of this sort is acceptable because warheads built under the RRW approach would not provide added military capability, so would not be classed as new warheads. Others are concerned that any new design, including one to replace a currently-deployed warhead, constitutes a new warhead.

Another issue may arise at the completion of the 18-month study. If the study or the subsequent design definition study concludes that the various RRW goals can be achieved while maintaining confidence in warhead safety and reliability, that conclusion would presumably have far-reaching results — a shift to RRW and consequent redesign and production of many new-design weapons and a restructuring of the nuclear weapons complex. Congress might at that point want an independent review of the design of RRW-1 (the SLBM replacement warhead) and the long-term path envisioned for the RRW program to provide added confidence that the warhead and program would both meet the goals assigned to them before proceeding further.

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[96] O'Brien et al., *Transforming the Nuclear Enterprise,* p. 6.

[97] As an example of how contentious "new weapons" are, see the debate on the amendment by Senator Feinstein to delete funds from H.R. 2419, the FY2006 Energy and Water Appropriations Bill, for the Robust Nuclear Earth Penetrator, in U.S. Congress. *Congressional Record*, June 30, 2005: S7781-S7794.

Appendix: Nuclear Weapons and the Nuclear Weapons Complex

This report refers to nuclear weapons design, operation, and production throughout. This Appendix describes key terms, concepts, and facilities as an aid to readers not familiar with them.

Current strategic (long-range) and most tactical nuclear weapons are of a two-stage design.[98] The first stage, the "primary," is an atomic bomb similar in concept to the bomb dropped on Nagasaki. It provides the energy needed to trigger the second stage, or "secondary."

The primary has a hollow core, often called a "pit," made of fissile plutonium (isotope number 239). It is surrounded by a layer of chemical explosive designed to generate a symmetrical inward-moving (implosion) shock front. A system injects "boost gas" — a mixture of deuterium and tritium (isotopes of hydrogen) gases — into the pit, and there is a neutron generator. When the explosive is detonated, the implosion compresses the plutonium, greatly increasing its density and causing it to become supercritical, so that it creates a runaway nuclear chain reaction. Neutrons drive this reaction by causing plutonium atoms to fission, releasing more neutrons. But the chain reaction can last only the briefest moment before the force of the nuclear explosion drives the plutonium outward so that it can no longer support a chain reaction. To increase the fraction of plutonium that is fissioned — boosting the yield of the primary — the neutron generator injects neutrons directly into the fissioning plutonium. In addition, intense heat and pressure cause the deuterium-tritium mixture to undergo fusion. While the fusion reaction generates energy, its purpose is to generate a great many neutrons. A metal "radiation case" then channels the energy of the primary to the secondary.

The secondary contains lithium deuteride and other materials. The energy from the primary implodes the secondary, causing fusion reactions that release most of the energy of a nuclear explosion.

The primary, radiation case, and secondary comprise the "nuclear explosive package." Thousands of other "nonnuclear" components, however, are needed to create a weapon. These include a case for the bomb or warhead, an arming, firing, and fuzing system, use-control devices, and more.

Nuclear weapons were designed, tested, and manufactured by the nuclear weapons complex, which is composed of eight government-owned contractor-operated sites as well as the federal agency, the National Nuclear Security Administration (a part of the Department of Energy) that manages the nuclear weapons program. The sites include the Los Alamos National Laboratory (NM) and Lawrence Livermore National Laboratory (CA), which design nuclear explosive packages; Sandia National Laboratories (NM and CA), which design the nonnuclear

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[98] U.S. Department of Energy, *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management,* DOE/EIS-0236, Sept. 1996, summ. vol., p. S-4. This page contains further information on nuclear weapon design and operation.

components that turn the nuclear explosive package into a weapon; Y-12 Plant (TN), which produces uranium components and secondaries; Kansas City Plant (MO), which produces many of the nonnuclear components; Savannah River Site (SC), which processes tritium from stockpiled weapons to remove decay products; Pantex Plant (TX), which assembles and disassembles nuclear weapons; and the Nevada Test Site, which used to conduct nuclear tests but now conducts other weapons-related experiments that do not produce a nuclear yield. These sites are now involved in disassembly, inspection, and refurbishment of existing nuclear weapons.

Pit production is the most controversial aspect of nuclear weapons production, and the one most closely linked to RRW. Rocky Flats Plant (CO) used to produce pits, but that work was halted in 1989 due to safety concerns. Since then, the United States has not made any pits that have been certified for use in stockpiled warheads — and has therefore been unable to make entire new warheads (excepting for a small number built shortly after Rocky Flats closed using pits that that plant had made). Los Alamos has established a small-scale pit production plant at its plutonium building, Plutonium Facility-4 (PF-4). PF-4 has produced several pits, but Los Alamos has not completed the work needed to certify them for use in the stockpile. NNSA anticipates that that work will be completed in FY2007, and that PF-4 will achieve a capacity of 10 pits per year beginning in FY2007. Los Alamos further believes that it would be difficult to expand PF-4's capacity enough to support the stockpile, though others challenge that view, arguing that if pit lifetime proves longer than anticipated, or if the future stockpile declines more than anticipated, a smaller capacity of an expanded PF-4 would suffice.

NNSA's proposed solution is to build a new Modern Pit Facility (MPF), with a capacity of 125 pits per year, to be operational beginning around 2021.[99] RRW might enable greater capacity at PF-4 or MPF by simplifying components and making manufacturing processes more efficient. Increased capacity at PF-4 might enable that facility to substitute for MPF, if pit requirements drop sharply, or to serve as a backup to MPF so as to avoid the disruption to nuclear weapons production that occurred with the shutdown of Rocky Flats Plant. Either of these options would require a capacity at PF-4 several times larger than the 10 pits per year currently projected for it.

[99] Information provided by NNSA, May 10, 2005.